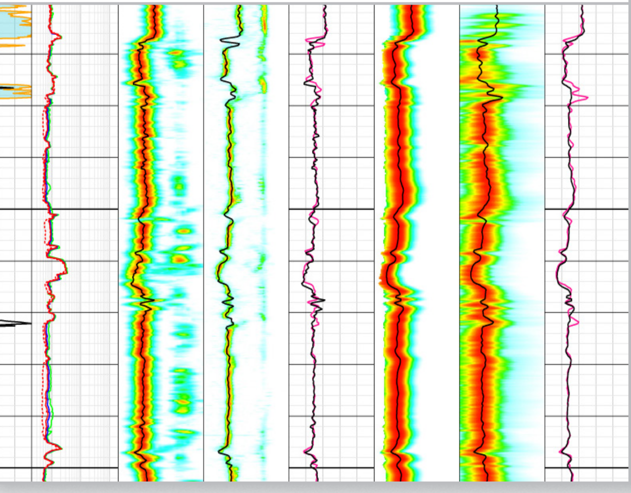
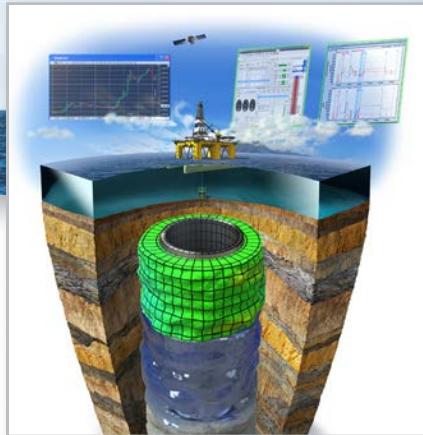
Schlumberger





SonicScope

MULTIPOLE SONIC-WHILE-DRILLING SERVICE

SonicScope

MULTIPOLE SONIC-WHILE-DRILLING SERVICE

Bring more confidence to your drilling operations.

Combining high-quality monopole and quadrupole measurements, the SonicScope* multipole sonic-while-drilling service delivers real-time compressional and shear slowness—along with Stoneley data—in any formation, regardless of mud slowness.

These measurements enable more confident decisions while drilling, helping you eliminate unnecessary casing strings, mitigate risk and improve safety, reduce nonproductive time, and save drilling days and costs.

Applications

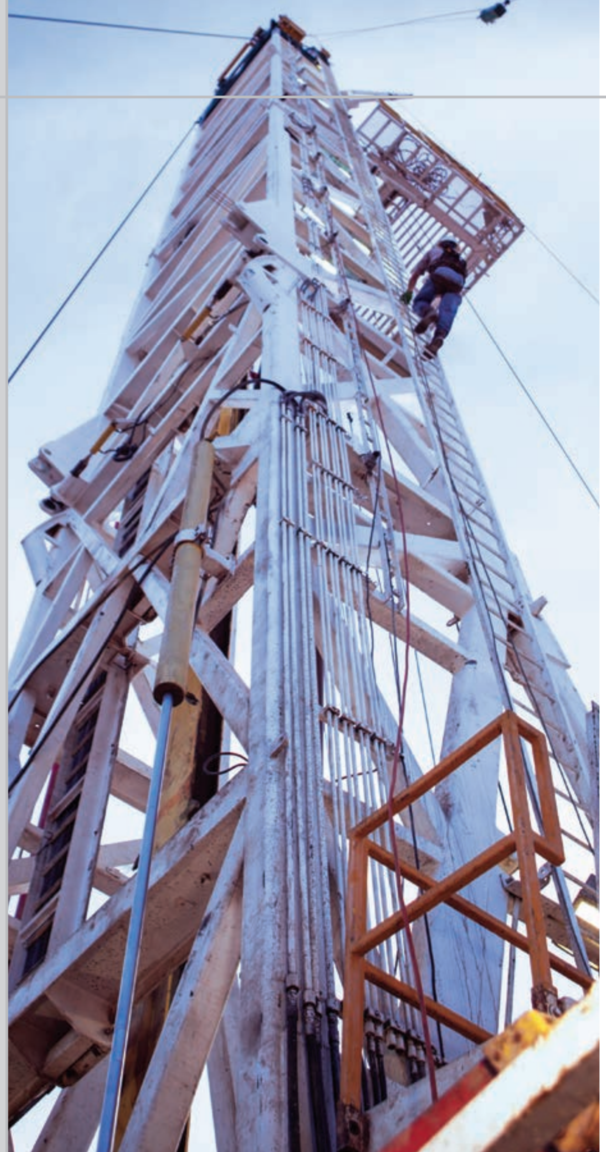
- Borehole stability and pore pressure monitoring
- Real-time and memory top-of-cement evaluation
- Cement bond index calculation
- Synthetic seismogram generation for seismic tie-in
- Porosity evaluation and hydrocarbon identification
- Fracture evaluation
- Perforation optimization

Benefits

- Mitigates risks and reduces costs by enabling real-time decision making
- Enhances production through optimized completion design
- Strengthens understanding of cement placement and quality
- Increases operational flexibility with the ability to run anywhere in BHA configuration—even with two reamers
- Improves understanding of wellbore strength and stability by obtaining compressional and shear data independent of mud slowness, in any formation
- Enables more effective mud-weight window management
- Takes station measurements during connections
- Minimizes well placement and casing positioning uncertainty with accurate sonic-to-seismic tie

Features

- 48 digitized receivers with refined interreceiver spacing to prevent aliasing at any depth
- Wideband multipole transmitter to eliminate complex source selection
- Flexible multimode, high-resolution acquisition recorded in 2-GB memory
- Slowness-time-coherence projection, surface labeling, and QC logs
- Real-time and memory Leaky-P models
- High-speed acquisition and real-time capability up to 1,800 ft/h for 6-in sampling
- Automatic labeling
- Real-time and memory monopole compressional and shear data
- Real-time and memory quadrupole shear data



SonicScope Service

Cement evaluation service

The cement evaluation component of the SonicScope service was developed to address the industry's need for well integrity assessment while reducing well construction costs. The two parts of the SonicScope service, cement detection and cement bond evaluation, enable rapid assessment of the cementing operation outcome and increase confidence before drilling out the shoe.

SonicScope Service combines high-quality monopole and quadrupole measurements for all hole sizes.

The SonicScope service offers a variety of logs and plots that enables a thorough quality-control process for data confidence.

Real-time wellbore stability

By allowing real-time mud-weight window management, the SonicScope service helps you manage wellbore stability while avoiding kicks and losses, reducing stuck pipe risk, and minimizing nonproductive time.

This evaluation, independent of formation temperature and salinity effects, helps you properly evaluate the pore pressure and fracture gradient so that the mud-weight window can be adjusted to mitigate drilling risks.

Real-time sonic-to-seismic tie

The SonicScope service's robust real-time compressional data can be used to build a synthetic seismogram that reduces well position uncertainty. Placing the bit on the surface seismic map enables you to make critical geosteering, landing, and geostopping decisions while drilling.

Real-time petrophysical evaluation

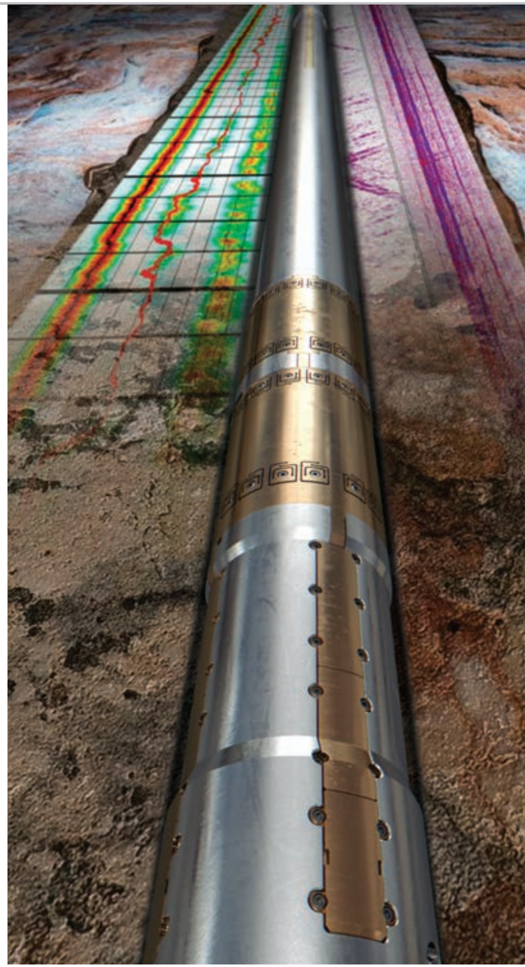
Robust compressional and shear measurements can help identify gas presence and estimate porosity without using radioactive sources that require complex logistics and added risk.

This makes the SonicScope service particularly advantageous in carbonate reservoirs because it only responds to interconnected porosity.

Completions optimization

A unique firing mode enables Stoneley wave acquisition while drilling, before any washout can develop. The Stoneley wave is sensitive to open, permeable fractures intersecting the wellbore along with formation fluid mobility and formation shear slowness.

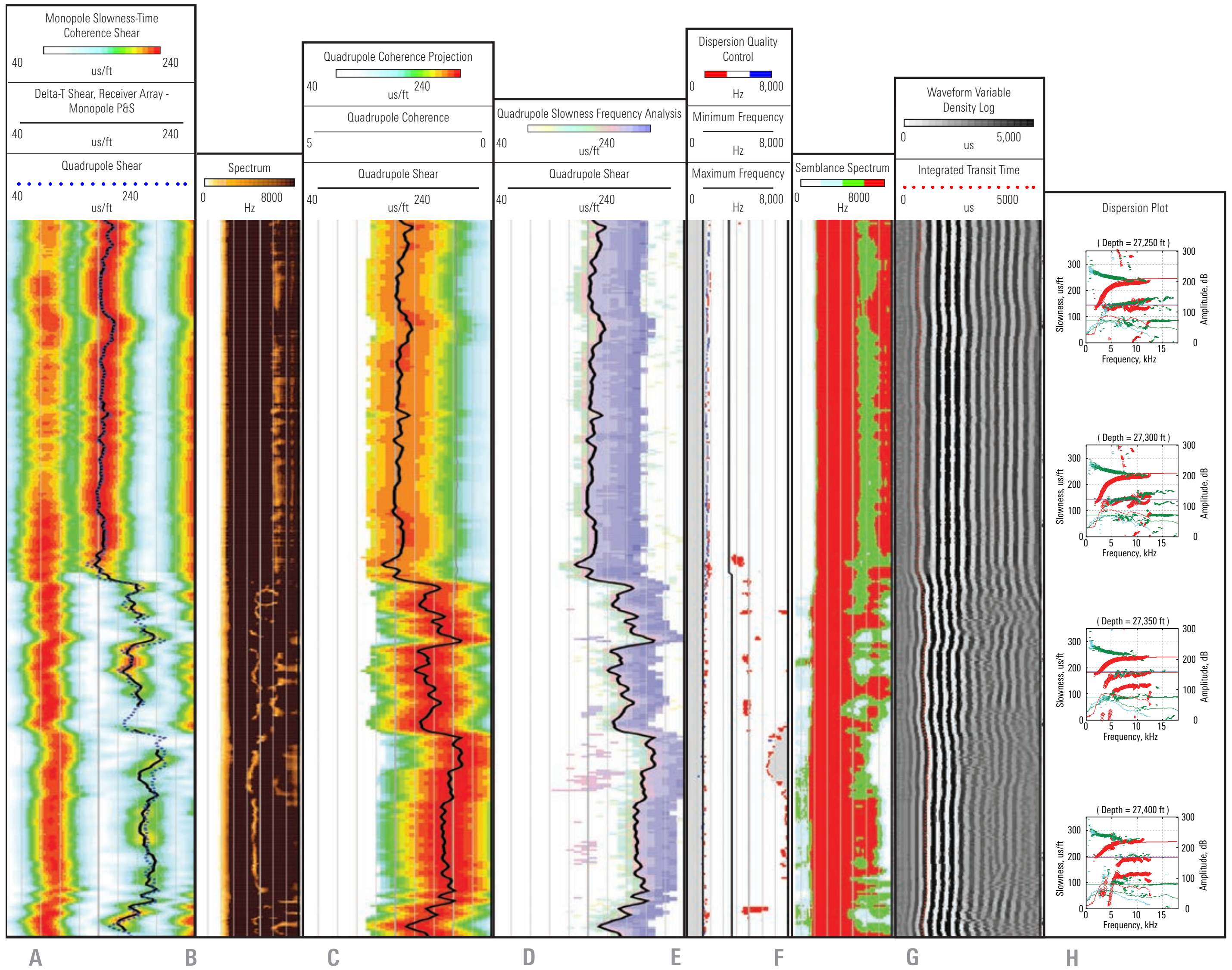
Integrating Stoneley measurements allows an accurate interpretation of reservoir quality, geology, fracture network, and rock mechanics, helping you optimize completions to maximize production potential.



The SonicScope service computes real-time and recorded compressional and shear (P&S) data in **both fast and slow formations.**

Comprehensive data quality control

To reduce uncertainties with data, the SonicScope service offers a variety of logs and plots as part of a thorough quality-control process, enabling operators to evaluate data from the acquisition of waveforms to the computed compressional and shear data.



A. Slowness time coherence provides full visualization of coherent arrivals and associated slowness.

B. Quadrupole spectrum details the frequency content of the waveforms; the darker the spectrum, the stronger the energy.

C. Quadrupole coherence projection represents the accuracy of the shear inversion.

D. Quadrupole slowness frequency analysis determines the energy of the propagating waves by projecting the dispersions onto the slowness axis at each depth.

E. Dispersion QC identifies how well the model from quadrupole inversion results fits the data.

F. Semblance spectrum highlights the frequency bandwidth over which the quadruple data is coherent.

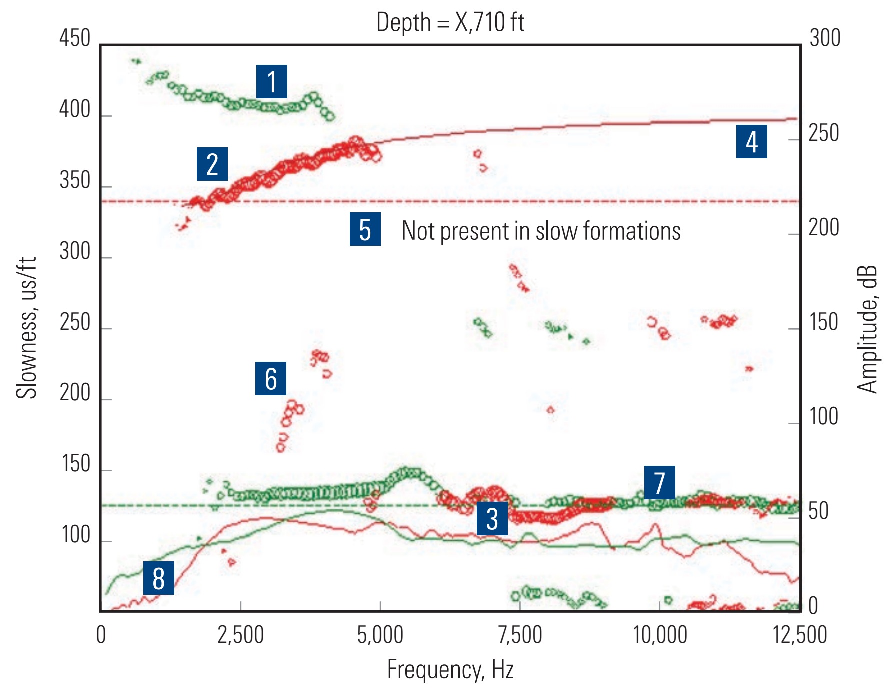
G. Waveforms variable density log enables QC of the waveform from a specific reservoir for compressional arrival and also checks if borehole washouts affect waveform amplitude.

H. Dispersion plot aids in understanding the different acoustic modes propagating in the borehole and is key for quality control of the processed slowness answers.

SonicScope service dispersion plot

Dispersion plots help you understand the different acoustic modes propagating in the borehole and are key for quality control of the processed slowness measurements. They allow validating that the proper mode has been selected in the case of monopole, quadrupole, or Stoneley as well as that the processing has been correctly applied.

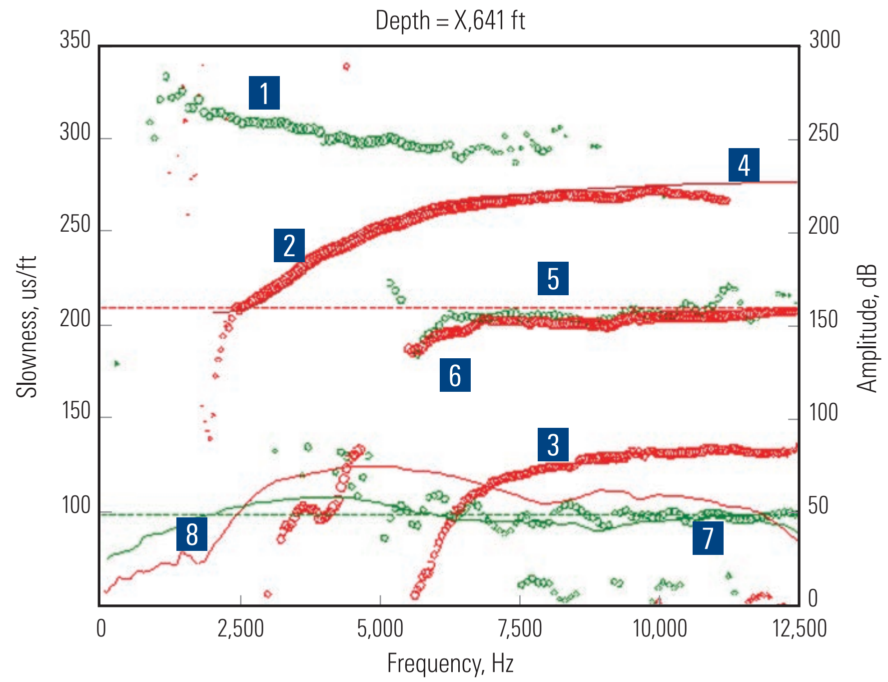
Slow Formation



Slowness dispersion plot in slow formations

- Compressional answer is identified in the higher-frequency range of the monopole source data as a nondispersive compressional head wave.
- Quadrupole shear answer is extracted from the low-frequency part of borehole quadrupole mode using model-based inversion.

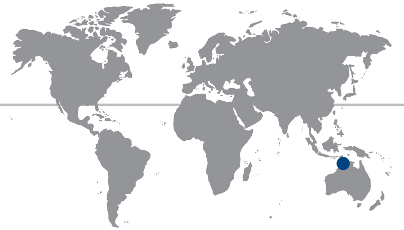
Fast Formation



Slowness dispersion plot in fast formations

- Compressional answer is identified in the higher-frequency range of the monopole source data as a nondispersive compressional head wave.
- Shear answer can be extracted from both monopole source data as a shear head wave, quadrupole source data, or both.
- Quadrupole shear answer is extracted from the low-frequency part of borehole quadrupole mode using model-based inversion.

1 Stoneley mode
2 Borehole quadrupole mode
3 Collar quadrupole mode
4 Modeled dispersion curve of borehole quadrupole mode (solid red line) for the shear slowness output from the inversion (dashed red line)
5 Shear head wave or pseudo-Rayleigh mode
6 Dispersive second-order quadrupole mode
7 Compressional head wave
8 Frequency spectra for monopole (green) and quadrupole (red)



SonicScope Service Enables Reliable Acoustic Data Acquisition in Complex Appraisal Well, Northern Australian Basin

Obtain high-quality LWD measurements in challenging appraisal wells

In a field in the Northern Australian basin, the upper formations consist of soft, unconsolidated sediments, while deeper zones pose drilling challenges such as reactive shale, circulation losses, and stick/slip. In previous wells, these attributes led to high risk of wellbore instability, BHA damage, stuck pipe, and more.

An operator planned to drill and evaluate an appraisal well. With limited evaluation data from the formations in the upper sections, the operator wanted to acquire high-quality LWD acoustic measurements that would reduce uncertainty and mitigate overall operational risk.

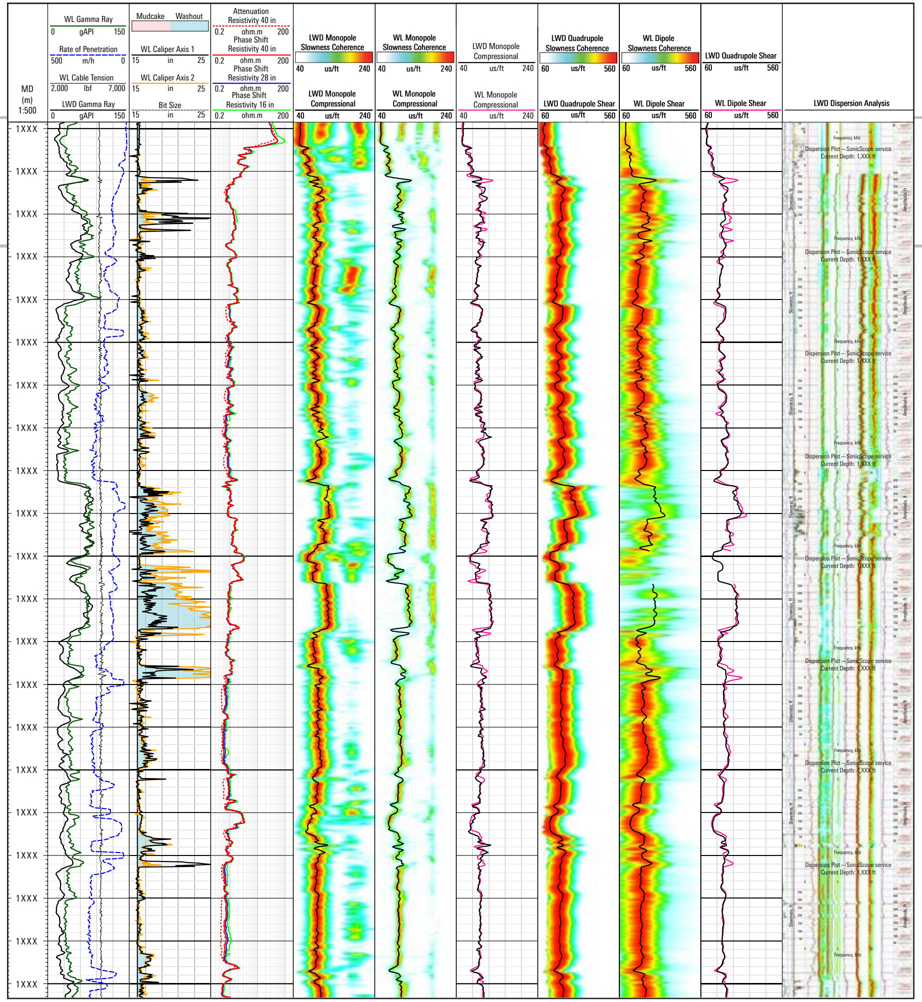
Deliver accurate, real-time acoustic measurements

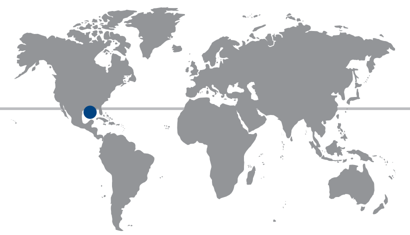
Schlumberger recommended using the SonicScope multipole sonic-while-drilling service in the 900 tool size with the arcVISION* array resistivity compensated service in the 16-in section. The SonicScope service delivers robust compressional, shear, and Stoneley wave data for accurate pore pressure and fracture gradient estimates, and the arcVISION service provides real-time resistivity, gamma ray, inclination, and annular pressure-while-drilling measurements.

Drilled with ROP up to 245 m/h while capturing high-resolution LWD data

The operator achieved an ROP of up to 245 m/h [804 ft/h] while drilling the 16-in section, doubling the planned ROP of 100 m/h [328 ft/h]. Using the SonicScope and arcVISION services, the operator was able to acquire accurate, reliable acoustic data—even in the unconsolidated upper section.

Standard monopole and quadrupole measurements were compared with Sonic Scanner* acoustic scanning platform data. This comparison helped the operator to understand the limitations of the borehole geomechanics, ensuring optimal well path designs for future development wells and, ultimately, improving project economics.





Offshore Operator Avoids Potential Kick, Improves Depth Control with Real-Time Acoustic Data, Gulf of Mexico

Mitigate exploration drilling challenges in the Gulf of Mexico

An operator was running an appraisal campaign in the GOM. While resistivity was previously the only available measurement for predicting pore pressure due to the large hole size in the shallow section, estimates from sonic data had proved more precise. The operator needed to acquire high-quality data to eliminate operational gaps while meeting directional and other drilling objectives.

Deploy BHA with LWD technology to achieve directional drilling and geological objectives

Because the planned well path would cross a sand layer, it was important to land the 17 ⅞-in shoe carefully and use real-time modeling to avoid the pressure ramp and mitigate risk. Before drilling, Schlumberger recommended that the operator deploy the SonicScope service, paired with the arcVISION array resistivity compensated service, across the 26-in, 18 ⅛-in × 21-in, and 16 ½-in × 19-in sections to capture high-quality LWD measurements. This would be the first time the service was run in the 26-in section worldwide.

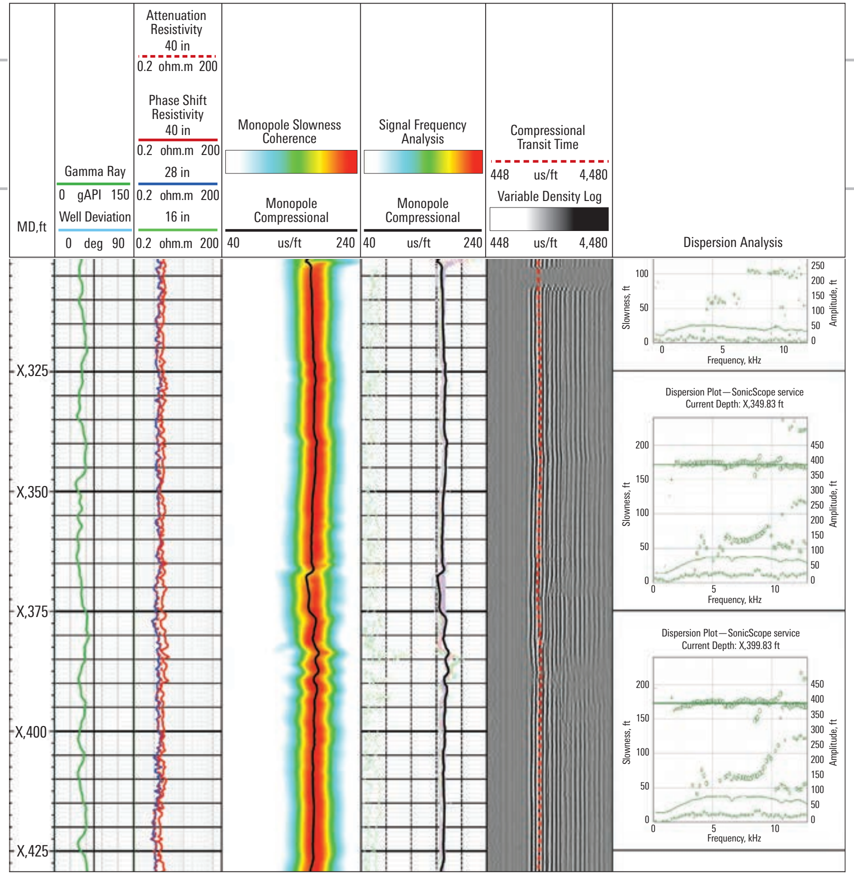
Operations commenced per the predrill plan, and the operator tracked the location of the anticipated pore pressure ramp in real time.

Prevented potential kick and avoided setting casing in known pressure ramp

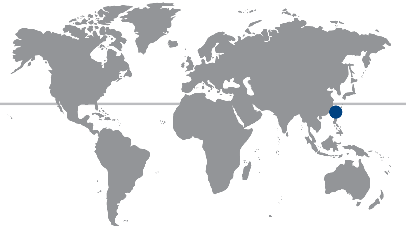
The use of the SonicScope service enabled an accurate seismic tie-in to a nearby well, which showed a possible 60-ft depth discrepancy in the pressure ramp's location. With this information, the operator decided to set the 17 ⅞-in casing 100 ft shallower to avoid drilling into the pressure ramp.

The high-resolution seismic tie, coupled with the real-time pore pressure prediction, enabled the operator to prevent a potential kick situation near the 17 ⅞-in shoe, saving an estimated USD 200,000 to 300,000 in drilling costs.

The operator used the high-quality acoustic measurements obtained using the SonicScope service to help confirm predrill models and avoid a potential kick through better depth control. The multipole sonic-while-drilling capabilities of the SonicScope service provided results that exceeded those achieved using alternative technologies in comparable situations.



The SonicScope service delivers reliable compressional data in 26-in tophole sections.



Operator Uses Multipole Sonic-While-Drilling Service to Drill Complex, Overpressured Shale Diapir

Shale formation with limited offset data

While drilling a shallow-water well offshore China, an operator needed to better understand the complex, high-pressure formation to successfully drill the 8 1/2-in section with 31.8° deviation in a high stick/slip environment. Without extensive data from a predefined model or offset wells, real-time pore pressure monitoring and seismic tie-in would provide the necessary information to help the operator drill the well and mitigate risk. By using advanced multipole sonic-while-drilling technologies that obtain robust real-time and recorded measurements, the operator could more successfully drill while obtaining insight for future wells.

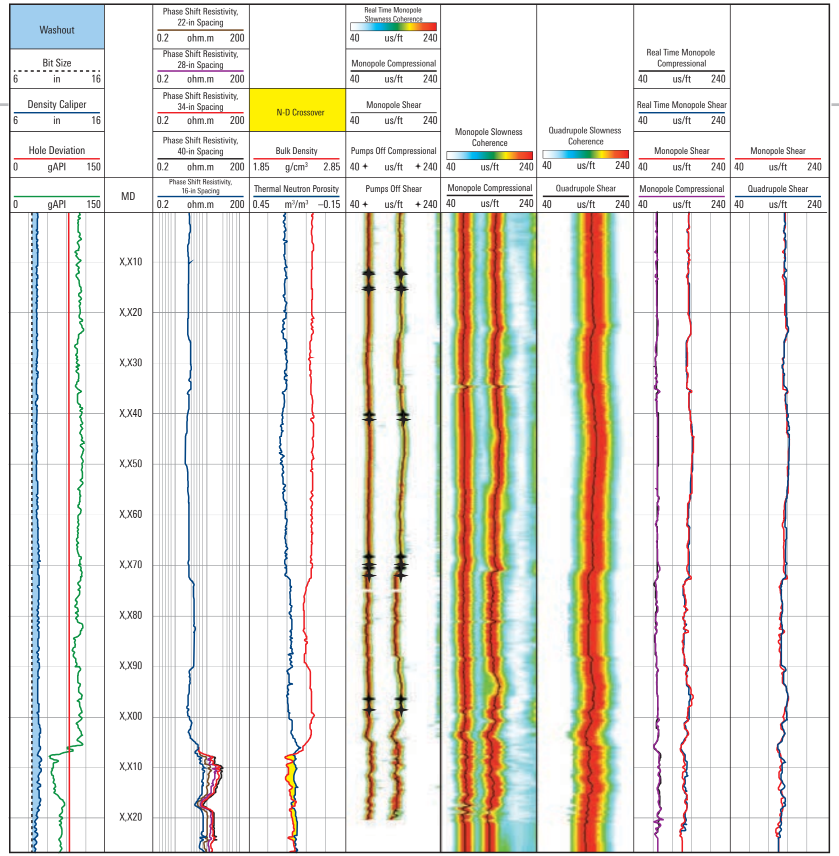
Multipole sonic data while drilling

Schlumberger recommended using the SonicScope service, which would enable more confident decisions while drilling, help mitigate risk, and save drilling days and costs.

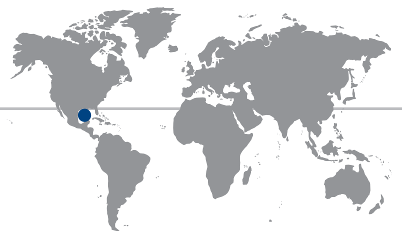
High-quality measurements

This operation marked the first time that the SonicScope 675 service was run in China. Using the service, the operator achieved drilling objectives, monitoring pore pressure in real time despite the high stick/slip risk in the shale formation. Using real-time sonic and density logs, high-quality synthetics were generated for accurate surface-to-seismic correlation in the time-depth domain.

The data obtained by the SonicScope service enabled the operator to optimize well placement and mitigate risk when drilling the complex, overpressured shale diapir. After pulling out of hole, data recorded by the SonicScope service was delivered to the operator's technical experts for future prestack AVO surface seismic inversions.



The operator concluded during the QC process that there was excellent data consistency between the real-time and record memory and well as the monopole and quadrupole measurements.



Dual-Reamer BHA Paired With SonicScope Service Saves Operator Logging and Reaming Runs

Efficiently develop ultradeepwater wells

An NOC planned to drill wells in an exploration campaign in the Gulf of Mexico. Successfully drilling and evaluating ultradeepwater wells is a challenging process involving narrower mud-weight windows, shallow geohazards, and seismic velocity uncertainties affecting pore pressure modeling. The operator needed to find an LWD solution that effectively mitigated these risks and enabled setting the casing at the correct depth.

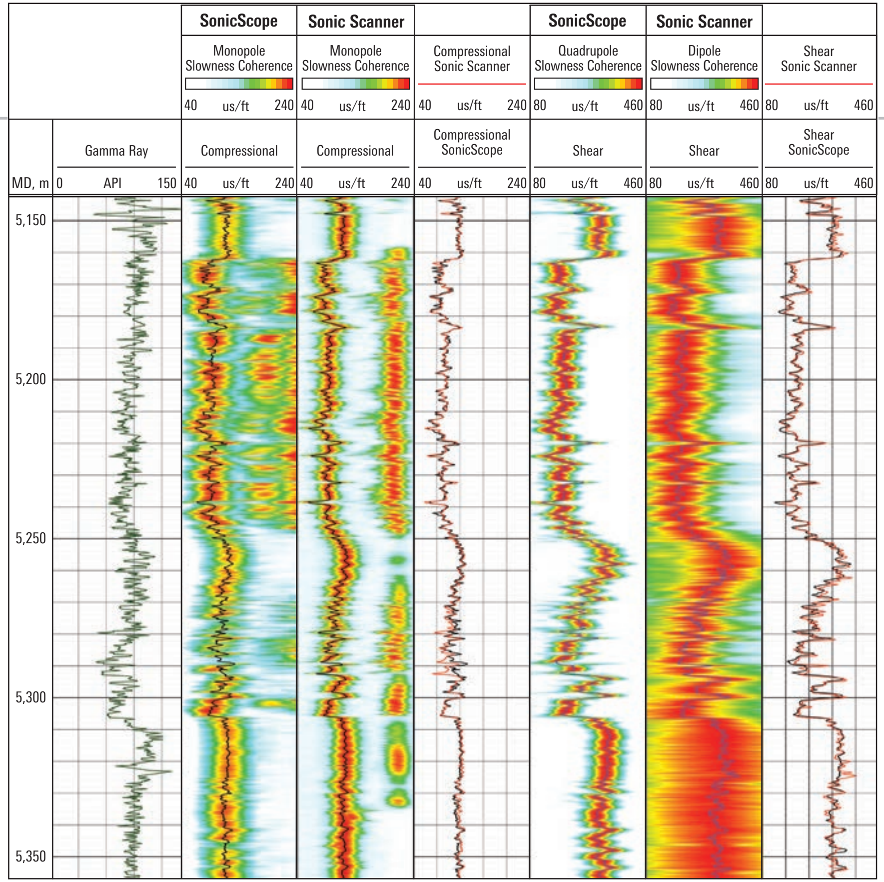
Customize BHA to acquire quality data

The operator and Schlumberger collaborated to develop a compact BHA configuration that included the SonicScope and a dual-reamer design. The SonicScope service in the 825 tool size would be placed closer to the bit to enable earlier detection of drilling hazards. Additionally, the shorter BHA would allow drilling a short pilot hole and placing casing at the needed depth.

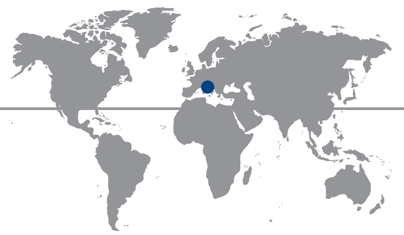
Meet demanding drilling objectives and save 2 days

The innovative BHA configuration saved 2 days of rig time by eliminating the need for additional logging and reaming. The quality log data provided by the SonicScope service was used to successfully drill the well and set the casing at the correct depth. The sonic data was used for real-time geomechanics and monitoring of the wells.

As high-quality, real-time data was acquired, the holes were underreamed to deliver a hole size suitable for running the casing designed in the well program. The technology provided by Schlumberger helped the operator drill the wells in an area with high-risk, unconsolidated formations in the shallow sections, along with increasing pore pressure and complex geology in the deeper sections.



The SonicScope service delivered wireline-quality data despite the acoustically complex drilling environment created by having two reamers on the BHA.



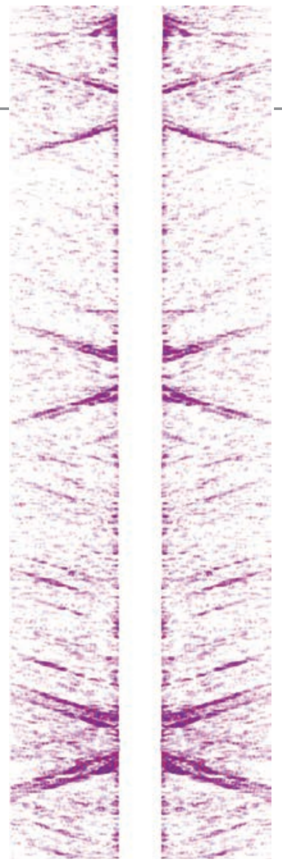
Full LWD Suite Optimizes Completion Design in High-Angle Offshore Wells

Improve production and reduce costs

An operator was drilling offshore shallow wells 4,000-m long with a horizontal section exceeding 3,500 m. The company worked closely with Schlumberger to improve production and minimize the costs associated with logging the long horizontal sections. A permanent openhole completion system was selected to enable placing multiple fracturing treatments in a single pumping operation, but the fracturing strategy using logs from nearby pilot or horizontal wells had not been adequate to optimize completion placement selection and to enhance the fracturing design. Drilling a vertical pilot well followed by target layer measurement of reservoir properties was not an option due to economic constraints.

Acquire and interpret high-quality data

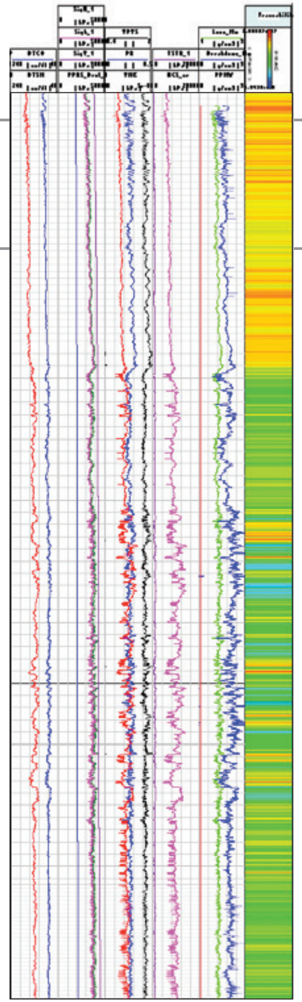
The operator geosteered the well using the PowerDrive X6* rotary steerable system and the PeriScope* bed boundary mapping service while recording triple-combo information for petrophysics; compressional and shear data for rock mechanics; and Stoneley data and images for fracture evaluation. LWD services included the SonicScope service, adnVISION* azimuthal density neutron service, and StethoScope* formation pressure-while-drilling service. The data were analyzed by Schlumberger experts, providing petrophysical evaluation (effective porosity, permeability, and oil/water contact location); stress variations for fracturing modeling and design; caliper variations for optimal packer setup; and open permeable fracture location to enhance production and to avoid the risk of draining water. The interpreted data were used to optimize the position of each of the five stages to maximize future production.



Optimized completion design

More than 3,000 m of data were recorded in one run and interpreted in less than 24 h to optimize the completions design using data acquired along the lateral section. A similar workflow is now being implemented on a well-to-well basis where multistage hydraulic fracturing is planned to enhance hydrocarbon production. The addition of rock mechanics information was crucial to better predict the fracture height and to avoid fracturing the water zone. The information was supported by a 3D mechanical earth model built using the Petrel* E&P software platform, which provided real-time data interpretation and helped maximize production.

Stoneley data for fracture analysis shows several strong reflections interpreted as open permeable fractures. Completion design was changed based on the knowledge of fracture location and the nature of the fluid contained.



Evaluation of rock mechanics over the lateral section based on sonic compressional and shear information. These properties are displayed in color from low stress (blue) to high stress (red).

Measurement Specifications	475	675	825	900
Monopole compressional and shear				
Quadrupole shear	Slowness (DT), full waveforms	Slowness (DT), full waveforms	Slowness (DT), full waveforms	Slowness (DT), full waveforms
Stoneley				
Compressional slowness	40 us/ft to mud slowness	40 us/ft to mud slowness	40 us/ft to mud slowness	40 us/ft to mud slowness
Shear slowness,[†] us/ft	60 to 600	70 to 700	70 to 700	70 to 700
Sensors	1 multipole transmitter	2 dedicated transmitters	2 dedicated transmitters	2 dedicated transmitters
Receivers	48 receivers	48 receivers	48 receivers	48 receivers
Downhole Memory				
Capacity, GB	1	2	2	2
Recording time	6 d at 10-s record rate recording all modes continuously	12 d at 10-s record rate recording all modes continuously	12 d at 10-s record rate recording all modes continuously	12 d at 10-s record rate recording all modes continuously
	10 d at 15-s record rate recording all modes continuously	18 d at 15-s record rate recording all modes continuously	18 d at 15-s record rate recording all modes continuously	18 d at 15-s record rate recording all modes continuously
Max. logging speed,[‡] ft/h [m/h]	1,800 [549]	1,800 [549]	1,800 [549]	1,800 [549]
Battery life[§]	5 d operating on battery only	7 d operating on battery only	7 d operating on battery only	7 d operating on battery only
Power supply	Battery or MWD turbine	Battery or MWD turbine	Battery or MWD turbine	Battery or MWD turbine
Combinability	Fully combinable with all Schlumberger tools	Fully combinable with all Schlumberger tools	Fully combinable with all Schlumberger tools	Fully combinable with all Schlumberger tools
Mechanical Specifications				
Hole size,[††] in [mm]	5⅝ to 8 [143 to 203]	8¼ to 10⅝ [210 to 270]	10⅝ to 17½ [270 to 445]	12.25 to 26 [311 to 660]
Collar OD, in [mm]	4.82 [122]	6.90 [175]	8.42 [214]	9.00 [228.6]
Max. collar OD, in [mm]	5.38 [137]	7.65 [194]	9.39 [239]	10 [254]
Collar length, ft [m]	30 [9.14]	32 [9.75]	32 [9.75]	32 [9.75]
Drill collar connection, in [mm]	4.82 [122] NC38 box	8.42 [214] 5½ FH Box	8.42 [214] 6⅝ FH Box	7⅝ H90 box

Screw-on stabilizers	Three-Blade	Three-Blade	Four-Blade	Four-Blade
Uphole and downhole distance apart, ft [m]	16.7 [5.10]	21 [6.40]	20.55 [6.26]	20.55 [6.26]
Max. OD, in [mm]	5.5 [140]; 5.75 [146]; 6 [152]; 6.5 [165]	8.25 [210]; 9.25 [235]	10.25 [260]; 12 [305]; 14.25 [362]; 17.25 [438]	12 [305]; 14.25 [362]; 17.25 [438]
Total flow area (TFA)[‡‡]	More than 35%	More than 35%	More than 35%	More than 35%
Operating Specifications				
Max. dogleg (sliding), °/100 ft	30	16	14	12
Max. dogleg (rotating), °/100 ft	15	8	7	6
Max. flow rate, galUS/min [L/min]	400 [1,514]	800 [3,028]	1,200 [4,542]	1,600 [6,056]
Pressure drop constant (*C*)[§§]	7,500	42,500	130,500	342,500
Max. pressure, psi [MPa]	25,000 [172.4]	30,000 [206.8]	30,000 [206.8]	25,000 [172.4]
Max. temperature, degF [degC]	300 [149]	300 [149]	300 [149]	300 [149]
HT option	350 [177]	na	na	na
Max. system shock level	30 min at shock Level 3 (50-gn threshold)	30 min at shock Level 3 (50-gn threshold)	30 min at shock Level 3 (50-gn threshold)	30 min at shock level 3 (50-gn, threshold)

na = Not applicable.

[†] Combining monopole and quadrupole acquisition—formation signal level required to measure shear is a function of noise level present while logging. Operating envelope for shear slowness is dependent upon hole size and mud slowness.

[‡] One-second sampling at 1,800 ft/h, or 10-s sampling at 180 ft/h, provides two samples per foot.

[§] Tool can also be run without a battery for unlimited time.

[††] SonicScope 825 service has been run in hole sizes greater than 9⅝ in.

[‡‡] TFA in in^2 is more than 35% of annular flow section (equivalent drill collar).

[§§] Pressure drop, psi = [(mud weight, lbm/galUS) × (flow rate, galUS/min)2] / C

SonicScope 475

SonicScope 675

SonicScope 825

SonicScope 900

SonicScope

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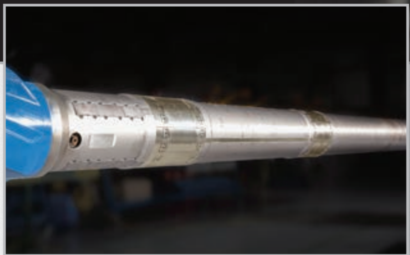
Drill with confidence.

High-quality monopole and quadrupole measurements in real time, in any formation

- Eliminate unnecessary casing strings
- Mitigate risk and improve safety
- Minimize nonproductive time
- Save drilling days and costs



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