CrossWave® Azimuthal Sonic Tool

Improves understanding of rock mechanics, anisotropy, and stress orientation

Applications

- 360° compressional/shear slowness and anisotropy borehole images
- Petrophysical geosteering
- Completion design optimization
- Geomechanical anisotropic characterization
- Pore-pressure evaluation
- Structural geological evaluation

Features and Benefits

- The tool provides 360° geomechanical characterization, which can be used to optimize hydraulic fracturing operations.
- The tool enables azimuthal sonic logging-while-drilling (LWD) and real-time azimuthal acoustic acquisition.
- The tool resolves slow and fast shear waves in anisotropic formations.
- The logs derived from the tool can improve fracture design based on the azimuthal geomechanical data.

Tool Description

The Weatherford CrossWave azimuthal sonic tool provides conventional and azimuthally focused measurements, as well as 360˚ sonic borehole images. Traditional acoustic data is collected in 16 azimuthal bins with fixed orientations. This allows the CrossWave tool to provide compressional, shear, and rock property borehole images, along with directional anisotropy, brittleness, and conventional acoustic data. This gives operators the information needed to characterize the reservoir and assists with the placement of stimulation stages.

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Specifications

Sensor

Size	4 3/4 in.	6 3/4 in.	8 1/4 in.	9 1/2 in.
Sensor type	acoustic receiver			
Measure point from bottom of tool	15.77 ft (4.81 m)	14 ft (4.27 m)		12.75 ft (3.89 m)
Compressional slowness range	30 to 270 μs/ft*			
Shear slowness range	30 to 270 μs/ft*			
Measurement accuracy	±1.5 μs/ft			
Vertical resolution, using full array	30 in. (76 cm)			
Number of receivers	6			
Inter-receiver spacing	6 in. (15.24 cm)			
Transmitter-receiver 1 spacing	6 ft (1.83 m)			
Transmitter frequency	10 to 15 kHz			

*Limited by mud slowness

Mechanical

Size	4 3/4 in.	6 3/4 in.	8 1/4 in.	9 1/2 in.
Maximum collar OD	5.375 in. (136.525 mm)	7.191 in. (182.651 mm)	8.753 in. (222.326 mm)	10.250 in. (260.350 mm)
Stabilizer blade diameter*	5.750 in. (146.050 mm)	7.750 in. (196.850 mm)	10.375 in. (263.525 mm) 15.500 in. (393.700 mm)	15.75 in. (400.05 mm)
Length	29.74 ft (9.065 m)	26 ft (7.93 m)	26.5 ft (8.07 m)	26.75 ft (8.15 m)
Weight	1,500 lb (680 kg)	2,900 lb (1,315 kg)	5,400 lb (2,449 kg)	7,500 lb (3,402 kg)
Top connection	3-1/2 IF box	4-1/2 IF box	5-1/2 IF box	7-5/8 Reg
Bottom connection	3-1/2 IF box	4-1/2 IF box	5-1/2 IF box	7-5/8 Reg
Make-up torque	9,900 to 10,900 ft/lb (13,424 to 14,780 N•m)	28,000 to 32,000 ft/lb (37,968 to 43,392 N•m)	53,000 to 56,000 ft/lb (71,868 to 75,936 N•m)	75,000 to 78,000 ft/lb (101,700 to 105,768 N•m)
Bending strength ratio	2.10	2.53	2.47	2.55
Maximum dogleg, rotating (° per 100 ft, 30 m)	12°	5°	4°	
Maximum dogleg, sliding (° per 100 ft, 30 m)	20°	11°	10°	8°
Equivalent bending stiffness (OD × ID)	4.75 × 4.12 in.	6.75 × 3.06 in.	8.25 × 6.89 in.	9.5 × 8.8 in.
Maximum operating temperature	302°F (150°C) standard; 329°F (165°C) optional			
Maximum operating pressure	20,000 psi (137.9 MPa) standard 30,000 psi (206.8 MPa) optional	20,000 psi (137.9 MPa) standard 25,000 psi (172.4 MPa) optional		
Maximum flow rate	350 gpm (1,325 lpm)	700 gpm (2,650 lpm)	1,600 gpm (6,005 lpm)	
Maximum sand content	2%			

*Stabilizer size dependent on hole size

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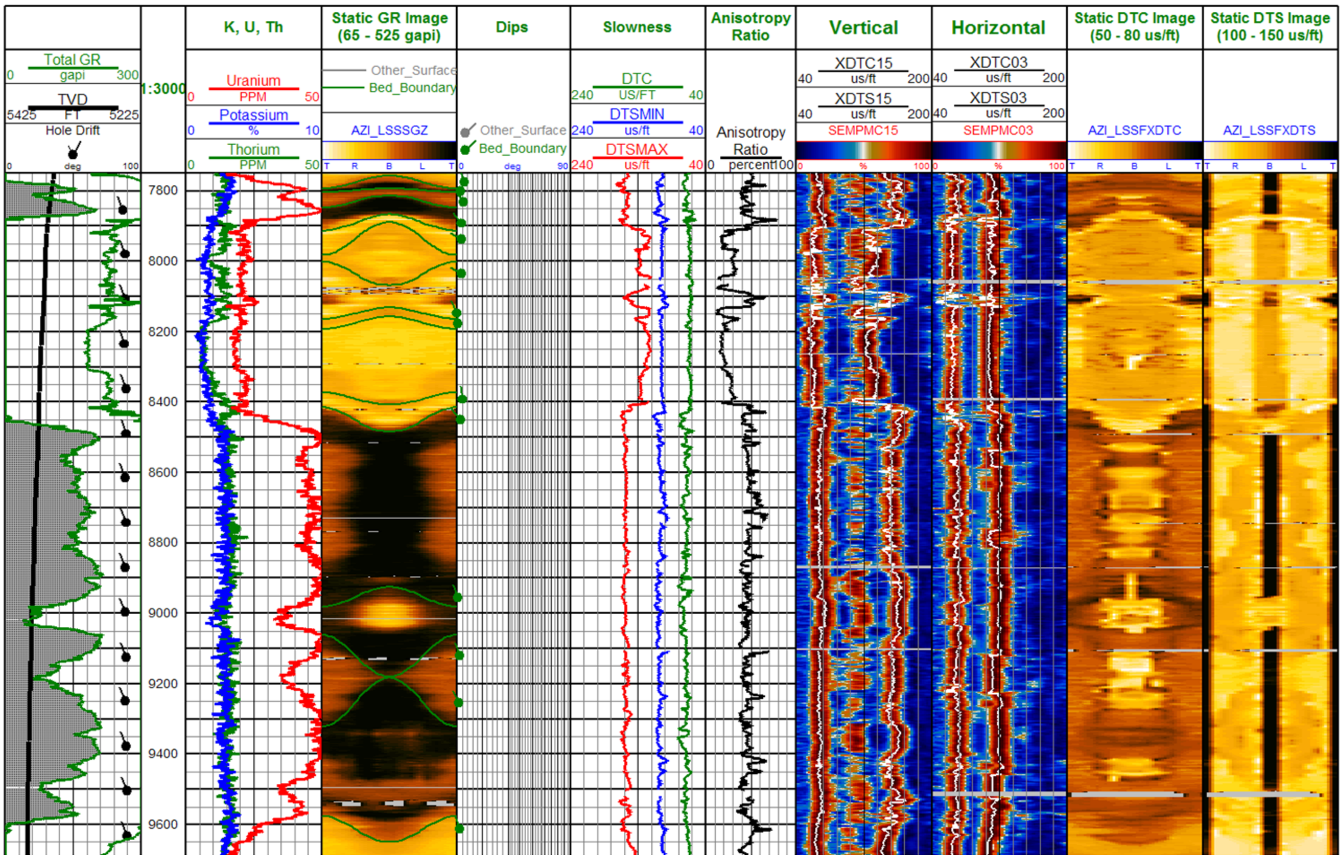
Logs



This CrossWave sonic log, which includes data from the SpectralWave® spectral azimuthal gamma ray sensor, shows that the gamma ray (GR) and compressional wave slowness (DTC) borehole images in Tracks 4 and 10 are similar. They reflect bedding variations in this generally uniform shale reservoir. The shear wave slowness (DTS) image in Track 11, which also reflects bedding variations, clearly shows the intrinsic vertical transverse isotropic (VTI) shear wave anisotropy. This is illustrated by the darker colors at the top and bottom of the wellbore (edges and center of the image log) that correspond to the slower vertical shear wave velocity. The lighter colors on the left and right of the borehole (center-right and center-left of the image) that correspond to the faster horizontal shear wave velocities. The transverse isotropy (TIV) acoustic anisotropy is quantified from the azimuthal acoustic variation in Track 6.