

# New sonic tool matches wireline data quality

A LWD program using sonic tools provides a South American operator with high-quality data with real-time access.

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As the industry moves into more complex reservoirs, real-time access to downhole data becomes even more critical to successful well placement for maximum recovery. Increasingly, operators rely on data from LWD tools in general and specifically on sonic tools to identify sweet spots, optimize wellbore placement, and plan the fracturing and stimulation programs.

Lately, scientific advances and improved processing techniques help provide higher data quality than before. The challenges get tougher as the reservoirs grow more complex.

Acoustic measurements, typically obtained from LWD sonic tools, can provide seismic/time-depth correlation, pore pressure prediction, formation porosity, and determination of formation mechanical properties. Compressional velocity and shear velocity of the formation are the two basic measurements from which the rock mechanical properties are computed. However, there are two factors that limit the quality of these measurements.

First, propagation of sound waves from the transmitter directly through the tool body (such as the drill collar) to the receiver can cause significant distortion to the acoustic signal. Since the speed of sound is typically faster in steel than in the earth's formation, it is critical to isolate and remove these distortions from a downhole computed sonic signal.

Compared to wireline tools, LWD tools have rigid collars that help them survive the harsh drilling environment (shocks, vibrations, and weight on bit). Wireline tools do not have the same problem since these are run after drilling and are made with slotted, rubber-filled housings that isolate the tool body noise.

Second, acoustic interference from the drilling environment such as downhole drilling noise during LWD operations adds to the signal distortion.

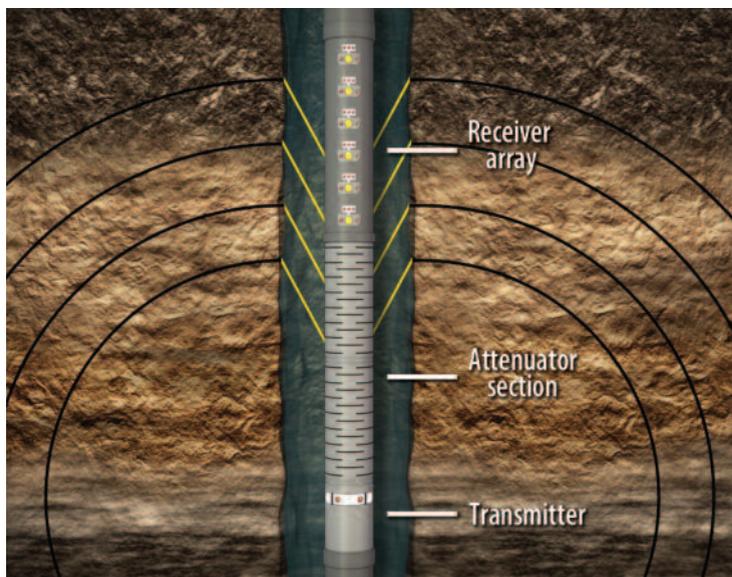
## Designing for improved quality data

Uncovering the secrets of the rocks while drilling is a major challenge. More and more tools are being devel-

oped to unlock the rock properties, turning the reservoir inside out.

Signal-to-noise ratio is the key to acquiring continuous and clean acoustic signals back to the receivers and overcoming the noisy drilling environment.

Weatherford's transmitter design was built to maximize the acoustic wave power as well as focus the wave into the formation (Figure 1). It has very high output power that reaches up to 6 kilopascals while firing.



**FIGURE 1.** With the ShockWave Sonic Tool, the transmitter is at the bottom of the tool and generates the acoustic waves (black). These waves then generate head waves (yellow) in the mud column, which are detected by the receivers (yellow buttons at the top of the tool). (Images courtesy of Weatherford International Ltd.)

On the receiver side, the array was designed to be very sensitive to acoustic waves coming from the formation and insensitive to acoustic energy traveling through the collar.

Along with a highly efficient attenuator section that isolates the receivers from as much drilling and collar noise as possible, these factors helped in getting a clean semblance projection as well as a strong first arrival.

## Processing the data

The tool processes the different waveforms from the various receivers downhole while drilling and saves them to the tool memory, which is later retrieved with the drill string and delivered to the operator. This gives a complete picture of the waves and how coherent these are to each other, which is called semblance.

As shown in Figure 2, the far right track (coherence track) is the semblance variable density log (VDL). The coherent arrivals are then processed by the engineer generating the compressional slowness curve (DTC) and the shear slowness curve (DTS), which are plotted in white on top of the coherence image.

The VDL is a 3-D chart of slowness in microseconds per foot versus depth, which, together with the color intensity, shows the coherence percentage.

On the other hand, the tool firmware compresses the semblance image for efficient real-time transmission to the surface even with the limited bandwidth of the LWD mud-pulse telemetry. The surface software then decompresses the dataset and enhances the contrast in the image, providing an output of a real-time semblance VDL log that is reliable and continuous.

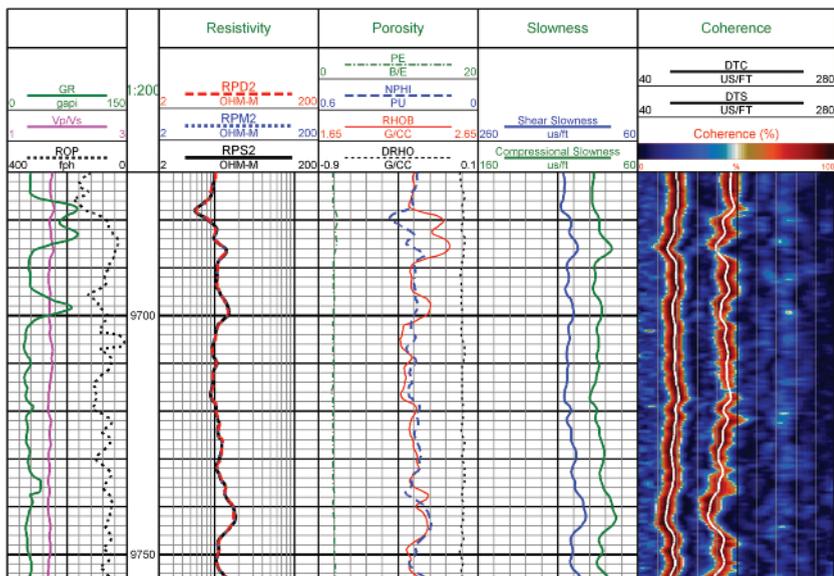
The field engineers use the high-quality VDL data along with the software interactive tools to generate the coherence arrivals and compressional and shear slowness curves. Important formation properties such as porosity, pore pressure, and rock mechanical properties can then be computed from the measured DTC and DTS values.

## South American well measurements

An operating company in South America was drilling in a new area and needed to improve its reservoir knowledge and geomechanical field information. The company decided to use the Weatherford ShockWave sonic tool to obtain this information for every first well in each cluster of wells.

The properties of the formation required in this particular case included Young's modulus (E), Poisson's ratio ( $\mu$ ), bulk modulus (K), and shear modulus (G). These would provide a better production evaluation picture and also help evaluate the formation mechanical strength to guide the production planning of the entire field.

These rock properties give a clear vision of the behavior of the formations in the reservoir, allowing the geologist and the geophysicist to complete their modeled picture on the behavior of the rocks to outside and localized stresses. These data also help in quantifying the production plan for the entire cluster to start with and the whole field at the end.



**FIGURE 2. A generic example showing the semblance VDL (dark blue column on the far right) together with the DTC and DTS slowness curves traced in white (DTC left on black and red and DTS right on black and red).**

The operator used the Young's modulus values to calculate the load-versus-strain relationship, the overburden pressure, and the force the rocks exert under specific strain in that particular reservoir. Knowing the localized stresses of the sweet spot facilitates the modeling of the frac jobs and thus optimizes the production planning for the entire field. And the operator used Poisson's ratio and shear modulus as stiffness measurements to determine the horsepower needed to frac the reservoir rock.

All these rock characteristics provide a clearer picture to the reservoir engineers and the geologists on how the rock will behave under different conditions, and many results can be obtained from them. These data aid in proper reservoir analysis and modeling as well as future planning of new wells.

The South American operator's results included improved production planning for the new field and also optimization of its reservoir model. The company was able to cut the number of wireline trips by using the sonic LWD tool and get rock mechanical data while drilling. **ESP**