Sonic-while-drilling

Slow formations combined with large boreholes made it difficult for existing sonic-while-drilling tools to provide compressional and shear measurements in deepwater environments. Jennifer Pallanich describes a tool created to provide real-time information about these reservoirs.

Applicable in most environments, Schlumberger’s SonicScope 825 service is intended for deepwater locations because it can be used in larger hole sizes and it delivers real-time answers to minimise drilling risk in unstable formations.

The company’s goal was to develop a “multipole tool to deliver reliable and continuous real-time compressional and shear measurements in all formations regardless of drilling fluid”, explains Eduardo Saenz, acoustics product champion and quality manager for drilling and measurements at Schlumberger. “These are measurements that only wireline could do a few years back,” adds Vivian Pistre, the company’s domain head for geophysics, acoustics and geomechanics for drilling and measurements.

Part of what an operator wants to know about the formation is whether the strength of the rock is strongly related to the compressional velocity with particle motion in the direction of the propagation, or shear with particle motion perpendicular to the propagation. A fast formation is one in which the formation shear is faster than the drilling fluid slowness, while a slow formation is one in which the formation shear is slower.

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Vivian Pistre, Schlumberger
a maximum pressure rating of 30,000 psi and maximum temperature of 150°C (300°F) — is deepwater markets, Saenz observes, "mostly because of the slow formations that we will be logging in these large boreholes". The SonicScope 825 service "gives answers previously only obtainable with cable conveyance", he notes.

In the past, however, severe instability problems while awaiting wireline logging to be performed could cause the hole to degrade so badly that this acquisition might be cancelled, leaving the operator without open hole data to characterise the formation, Pistre says.

According to Schlumberger, pore pressure, geomechanics and well integrity are only a few examples of the applications for this tool.

Additionally, Saenz says, operators use the resultant data to calibrate their pore pressure window and reach total planned depth without wellbore instability.

In terms of geophysics, the tool is used to position the drill bit on the seismic footprint and identify the geological layers and potential hazards.

"If your seismic has a level of uncertainty, with this tool you can tie into the seismic and reduce that uncertainty," he points out.

When it comes to completions, the tool can be used to evaluate "where the top of your cement is inside the casing and to make sure you have zonal isolation".

For formation evaluation, the tool can be used in conjunction with other measurements such as a neutron tool to identify secondary porosities.

Three modes
The SonicScope 825 fires in three different modes to deliver data. In the first, it fires in high-frequency monopole to deliver compressional data in all formations and shear data in fast formations. In the second, it fires in low-frequency monopole for Stoneley acquisition for fracture analysis. Finally, it fires in quadrupole to deliver shear slowness data in slow formations.

"A combination of these three firing modes gives this technology the capability to deliver continuous compressional and shear data in all formations," Saenz explains.

In a monopole firing, there is one pressure wave around the tool. Saenz compares the monopole to a rock dropping in still water and generating concentric circles.

A quadrupole firing has four 90-degree quadrants of alternating positive and negative pressure.

"As you rotate around the tool, the pressure changes create micro-deformation to the borehole, elongating in one direction and contracting in the perpendicular one," Pistre says.

The tool's hardware includes two dedicated wideband transmitters. An attenuator section is optimised for cleaner acoustics. There are 48 digital receivers arranged in four strips of 12.

"The signal is digitised at the sensor," Saenz says. "That's a new development, providing noise-free data." Previously the signal would have been digitized at the electronics cartridge. The 4-inch inter-receiver spacing is said to prevent aliasing, or detection of erroneous slowness values.

The tool uses stabilisers..."
Gamma Ray, Ultrasonic Caliper, and Propagation Resistivity Measurements

Track 1  Slowness-Time Coherence
Track 2  Quadrupole Spectrum
Track 3  Quadrupole Coherence Projection
Track 4  Quadrupole Slowness Frequency Analysis
Track 5  Dispersion Quality Control
Track 6  Semblance Spectrum
Track 7  Waveform
Track 8  Dispersion Plot

QUALITY CONTROL: The SonicScope quality control log provides a set of comprehensive plots used to fully understand the data processing workflow.

designed to centralise the tool and provide cleaner acoustics. Adjustable centraliser sizes are designed to provide high-flow areas and avoid drilling risks. Downhole memory capacity is 2GB, enabling long runs on downhole turbine power. The tool can also operate on battery only for seven days. Finally, a high-performance processor records, computes and transmits answers in real-time. Data can be delivered up to 960 microseconds/foot and used for correction of seismic time-depth conversion. “All this put together basically means that we have a technology that requires minimal operator input and gives us the capability to run anywhere in the bottom hole assembly,” Saenz says.

Checking quality
“As we are processing the data, we do our own quality control,” Saenz explains. “Some of the important deliverables with the data we provide are the quality control plots required for the client to validate the log on the data itself. In this way, they trust the answer and where it is coming from.” That is vital, he adds, because the data is subsequently used as an input in multiple applications. “The more accurate the input data, the more accurate the output will be.”

The waveform data generated can be counted in gigabytes, Pistre notes. Data acquired in real-time can be transmitted via wired drill pipe and drilling fluid pulse telemetry. When “only bytes” can be transmitted in real-time from the huge volume of information acquired through the service, the necessary information for real-time quality control is sent.

Changing approaches
In the mid-1990s, acousticians at Schlumberger analysed the knowledge gained via sonic technology that had been developed for wireline as well as a newly developed LWD sonic tool that was being deployed.

“Things were complicated, and we needed to change the way we were looking at the technology,” Saenz recalls.

The acoustics in the borehole are a combination of the signal
propagating in the rock — information Schlumberger wants to provide to its customers — along with interaction from the borehole, which can vary widely in terms of size and fluid content, and interaction with the tool, for which the presence cannot be simply corrected or could be wrongly assumed to be transparent.

Put simply, the laws of physics dictate certain limitations. “The sounds propagate away from the borehole, so we could not measure... with previous technology,” Pistre notes.

Taking a new tack, Schlumberger started designing sonic tool components — that is, the transmitters, receivers, electronics and mechanical devices — with detailed characterisation and precise modelling of their impact on the acoustics. The service company verified the impact of the components in a test facility using a series of artificial formations built specifically for such tests.

“We need to understand our tool perfectly and know its effects on the acoustic measurement to include it in the processing of the measured data. In one phrase — tool predictability,” Pistre says.

The first tool that resulted from the new approach was the wireline Sonic Scanner acoustic scanning platform, which Schlumberger commercialised in 2005. Engineering work on the SonicScope IWD concept and its component tools began in 2001. In 2008, Schlumberger commercialised the SonicScope 475.

The SonicScope 825 draws on the acoustics structure and processing design of the wireline Sonic Scanner platform and the SonicScope 475.

“The technology was tested in a variety of drilling environments for many different operators around the world — initially in deepwater wells, then tight gas reservoirs, shale plays and other challenging environments where other conveyance methods were uneconomical,” Saenz says.

“We have been testing the tool for the last few years, and looking at what the market needs and the tools sizes needed,” he adds. “The answers the technology could provide were in line with the needs of the deepwater market.”

Schlumberger had made over 150 runs globally when it commercialised the 825 service in October 2013.

One of the deployments was off Malaysia, where an operator wanted to reduce seismic uncertainty for a very soft deepwater formation. Using the SonicScope 825 service, the operator drilled four wells “in close proximity to acquire time-depth information in real-time to reduce this uncertainty,” Saenz reports. “We were able to deliver repeatable compressional and shear information about the formation.”

The information the tool provided enabled correction of the time-depth conversion to accurately identify geological layers and potential drilling hazards, he adds.

Schlumberger says it is looking into the development of additional tools to address other borehole sizes to round out the SonicScope family.

“The end objective,” Pistre says, “is to be able to do with LWD sonic what can be done with wireline, and more, so that operators have the choice of the technology and conveyance they prefer to use or that the environment allows them to run.”