Seismic while drilling keeps bit turning to right while acquiring key real-time data

By Jerry Greenberg, contributing editor

UNDER DEVELOPMENT since 1988 and commercialized in 2003, the Schlumberger seismicVISION seismic-while-drilling service (SWD) enables operators to make seismic measurements during the drilling of the well. Operators can thus reduce uncertainty, optimize drilling decisions and improve safety. Previously, in most environments, this meant stopping the drilling process and running a wireline survey.

Since its commercialization, Schlumberger has been working on enhancements, the latest of which is the capability to send real-time waveforms from downhole to the surface. Previously, waveform information was retained in the tool’s memory to be retrieved when the BHA was tripped out of the hole. Now, with real-time waveform capability, waveform data can be accessed through mud pulse telemetry to increase the quality of the information, further reducing uncertainty and resulting in even better decision making, the company says.

EARLY SEISMIC TECHNIQUE

Prior to seismicVISION, the only real-time seismic technique used noise generated by the drill bit while drilling as a seismic source, with receivers placed on the surface to record borehole seismic data. The technique has been tested and used in different downhole environments, and has been useful in optimizing drilling processes and reducing costs. However, there are operating limitations.

“The industry-recognized limitations are that it doesn’t work very well at great depths, it is difficult to deploy offshore, and it does not appear to work well with PDC bits,” said Andy Hawthorn, domain leader: acoustics, geophysics and geomechanics for Schlumberger.

SEISMICVISION MARKETS

The system can be used both onshore and offshore. It has been primarily used in deepwater, but has also been deployed in shallower waters.

“The two key markets are deepwater risk reduction and the correct setting of casing strings,” Mr Hawthorn said. “Setting casing strings is not only about setting the event, it means optimizing the casing string so that you may control the pore pressure/fracture gradient window further down the well.

“Anything you can do to improve your drillable window in terms of mud weight control means you may be able to push your next casing string further, or potentially eliminate an intermediate, or planned casing string.

HOW IT WORKS

Technically, the system’s check-shot surveys provide direct measurements of seismic travel times from the surface to the survey locations along the wellbore trajectory. These measurements are used to calibrate the depth of the surface seismic image at the locations. The data from the check-shots and the data from the surface seismic are utilized to plot and track the bit’s position on the seismic image used to plan the well.

Simplified, the real-time check-shot data is used to place the bit on the seismic to aid bit navigation, select casing points and prepare for hazards ahead of the bit such as faults, pore pressure changes or formation variations.

The tool contains a processor and memory and receives seismic energy from a conventional air gun array located either on the drilling rig or a source vessel. After acquisition, the seismic signals are stored and processed in the tool, and check-shot data and quality indicators are transmitted uphole in real time through a connection with a TeleScope MWD telemetry system. The time/depth data are used to position the well on the seismic map at the wellsite or offsite. Waveforms are recorded in the tool’s memory for vertical seismic profile (VSP) processing and can be processed on site or sent to a central processing location for interpretation that provides a seismic image of the next section to be drilled.

A patented technique enables source activation and data acquisition during pauses in the drilling operation when the downhole environment is quiet, such as during pipe connections while drilling and tripping. As a result, source activation is typically completed with no interference to the drilling operations.

The tool has been proven in a wide range of environmental and operating conditions, including in wells with vertical depths of more than 30,000 ft, in open-hole and cased-hole sections and in hard and soft formations. It has been used successfully from moored and dynamically positioned rigs and source vessels and in deep and shallow water.

The tool can operate in temperatures up to 150°C (302°F) and in pressures up to 25,000 psi and is available for hole sizes from 8 ¼-in. to 26-in.

CONNECTING DOWNHOLE WITH THE SURFACE

The system is nearly identical to the wireline service using the same surface source and downhole sensors. The main difference is that there is no direct cable connection between the tool and the surface.

The technology is based around synchronized clocks. The primary technological breakthrough was building a downhole clock accurate enough to measure milli-
liseconds but also be rugged enough to survive downhole.

“The clocks are synchronized to within three microseconds at the surface,” Mr Hawthorn explained. “Conceptually, it is a very simple tool, but it is technologically very difficult. The one enabling technology is the high-precision clocks that can survive in the drilling environment.”

Hydrophones and geophones in the tool measure the incident energy from the surface source, process the waveforms downhole to determine the first break time and the data is sent uphole via mud pulse telemetry.

At the surface, the drilling engineer, who is typically sitting in the wireline unit or other location with a view of the rig floor, decides whether to fire the air guns. If the driller is making a connection and the downhole tool is stationary, the engineer enables the automatic gun-firing software that fires the air guns exactly 15 seconds apart at the start of the event window.

The downhole tool analyzes the incident energy, and an algorithm decides whether there is a first break. If a check-shot is deemed good, it is placed in a buffer. While each shot is recorded in memory for processing later, the real-time measurement relies on at least three sequential shots to arrive at the tool at the same time offset in the event window, and also have the same wave shape. This is to avoid the tool triggering on noise generated by the rig. If at least three shots are seen, the tool starts to stack the waveforms and continues to stack on each firing. Once the mud pumps resume, the tool calculates the first break time from the stacked waveform, passes the data to the MWD and the data is sent uphole immediately after the survey.

Since the bit can be seen on the seismic map in real time, the driller can drill the well very close to events seen on the seismic map. For example, casing can be set very close to where they ideally should be set. In some cases, this could mean the elimination of a casing string, resulting in a high cost savings.

If a core is to be run, the well can be drilled very close to the interface where the core is needed prior to pulling out of the hole to run the core tool. This eliminates a large amount of unnecessary hole to be drilled if drilling had stopped too early prior to pulling out of the hole. It also can eliminate the possibility of drilling through the required coring zone, resulting in reduced or missed core data.

**REAL-TIME WAVEFORMS**

Seismic while drilling provided the first opportunity for a true look-ahead potential, providing a warning prior to drilling into a potential problem zone or target. The system’s initial capability was a real-time check shot service with all waveforms recorded in the downhole memory for processing after tripping out of the hole.

Today, the tool has the capability to send up to two seconds of partially processed stacked waveform data uphole via mud pulse telemetry in relevant drilling time. This provides for expert quality control on the first arrival, tightening velocity measurements and mitigating against acoustically noisy data. It also allows for the possibility of a limited look ahead from the tool.

Schlumberger began working on transmitting real-time waveforms in 2004 and introduced the service in 2006. The company said it stayed quiet about its accomplishments pending testing and to ensure operators were comfortable making real-time drilling decisions.

The waveforms can be sent via satellite to an operations support center for geophysicists to interpret. The geophysicist can determine, in real time, whether the drilling model should be changed, which changes the actual drilling process.

Figure 2 shows an example of real-time waveform data transmitted uphole via mud pulse telemetry. This increases the level of quality control as the first break can be picked up by experts on surface rather than relying on the black box processing of the tool downhole.