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Pitch-catch scores a home run

An innovative combination of acoustic measurements promises to resolve the toughest hydraulic isolation problems, and much more.

By DICK GHISELIN, Technical Director

The new Scanner family of wireline logging tools from Schlumberger answers the most fundamental of exploration and production questions: Where are the hydrocarbons, will they produce, and what other fluids are present? With their ability to perform rock and fluid characterization, the tools are able to perform more complex measurements in increasingly difficult environments than ever before.

By scanning radially and orthogonally at multiple depths of investigation, the tools provide a true 3-D image of the volumes surrounding the borehole, helping to resolve difficult challenges posed by formation heterogeneity, anisotropy and asymmetry. They identify and discriminate formation fluids as well as influxes from drilling fluid or its filtrate. In addition, they can image natural fractures pierced by the well bore as well as those induced by drilling operations.

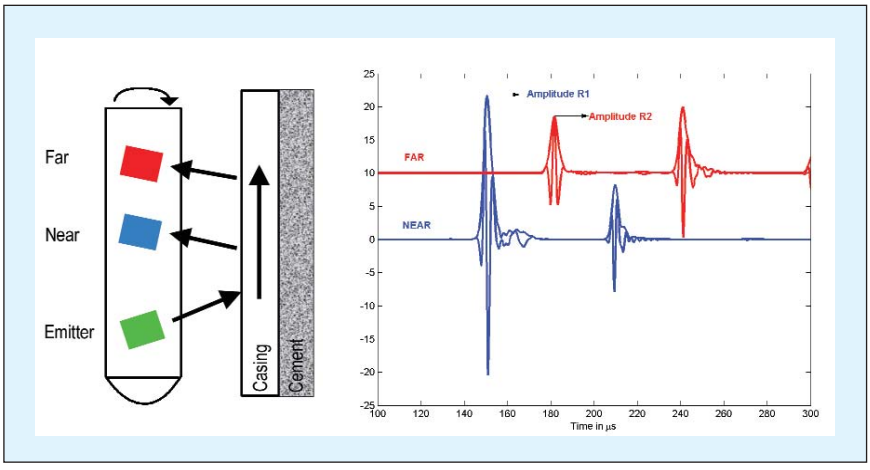

Figure 1. Pitching and catching a sound wave in casing, the attenuation caused by the cement sheath can be determined. (All images courtesy of Schlumberger)

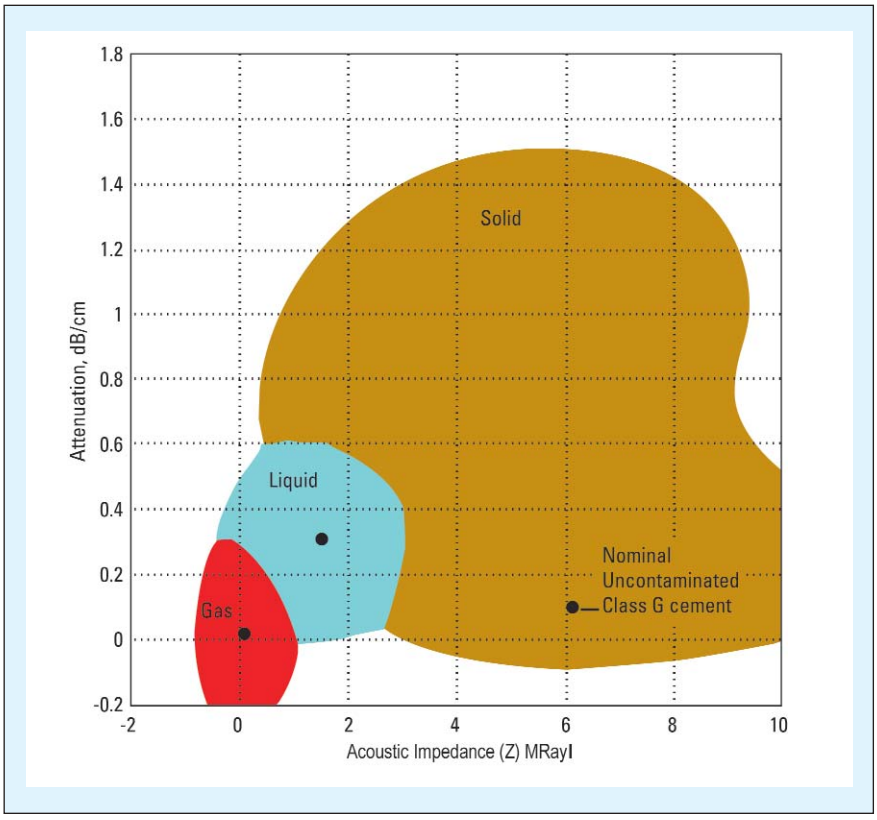

Figure 2. Phase overlap prevents precise material identification with a single measurement.

An impressive pedigree

The Scanner family includes the Rt Scanner, the Sonic Scanner and the MR Scanner. The Rt Scanner employs triaxial receivers located at a common measure point to measure vertical and horizontal resistivity at multiple depths of investigation while simultaneously solving for formation dip at any well deviation. The Sonic Scanner is a complete acoustic scanning platform able to measure compressional and shear slownesses using borehole compensated monopole and crossed-dipole transducers. Measuring azimuthally, radially and axially, and sweeping through a broad frequency range, the tool provides precise detail at multiple depths of investigation that resolve formation and reservoir questions for explorationists, drillers and reservoir engineers. The MR (Magnetic Resonance) Scanner profiles fluid volumes and saturations and provides direct hydrocarbon charac-

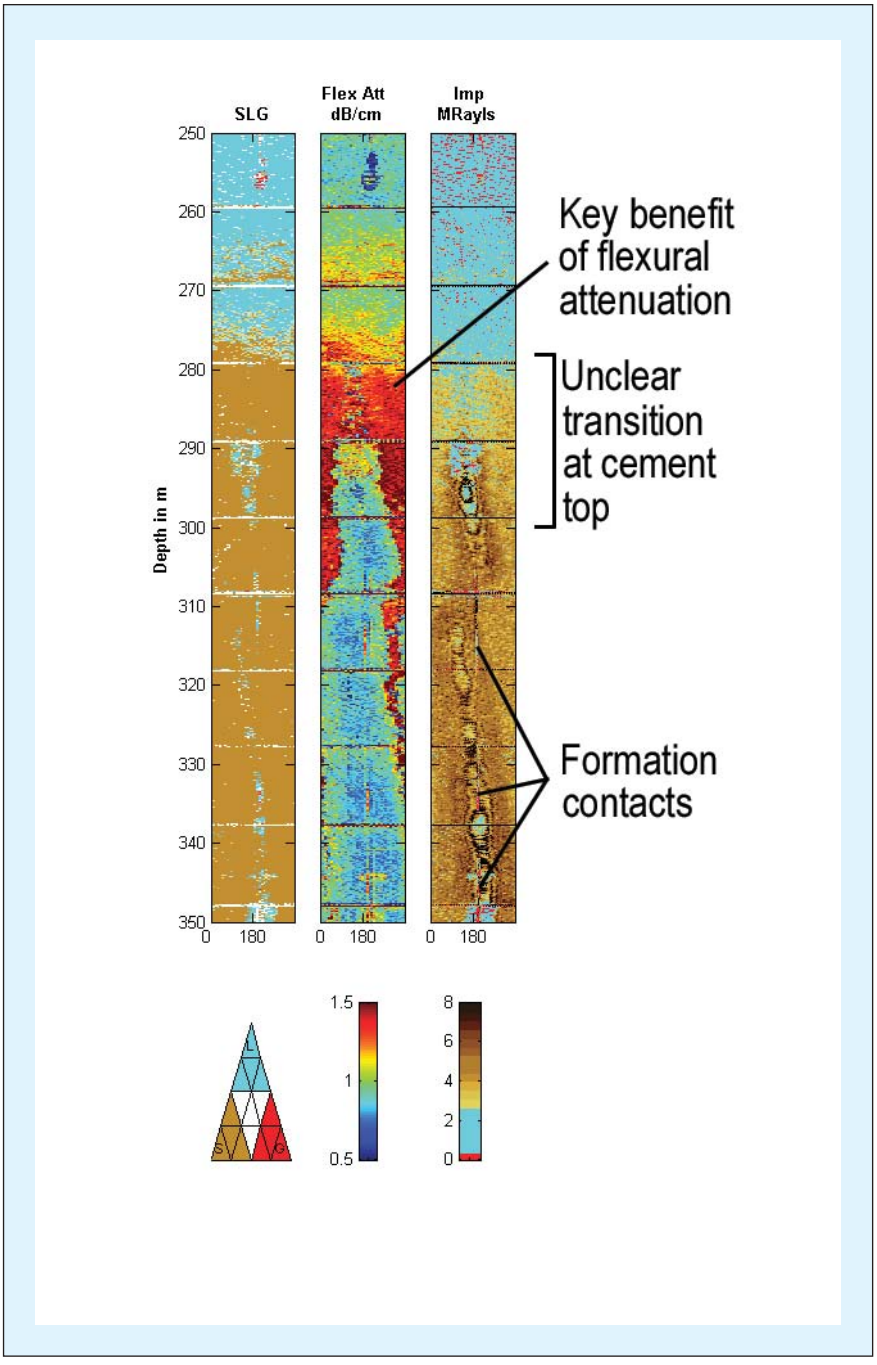

Figure 3. By themselves, acoustic impedance (right) and flexural attenuation (center) plots cannot resolve ambiguities. The SLG Isolation Scanner plot (left) clearly defines the transition zone at the cement top.

terization in any environment, including rugose boreholes, varying formation water resistivities, heavy- and oil-based muds, low-contrast pays and thin formations.

Contrasting Scanner tools to Imaging tools, Schlumberger's Bill Wright said, "The imaging tools provide a picture of the borehole that's like looking at a piece of wallpaper, whereas the scanners are looking at volumes of formation starting at the borehole or casing interface and projecting radially to various depths into the formation. It's a step-change in our ability to evaluate heterogeneous volumes of rock or cement in the immediate vicinity of the borehole."

A new addition

The latest member of the Scanner tool family is aptly named. The Isolation Scanner answers the fundamental question of hydraulic isolation, but does so in a wide array of environments. Earlier cement evaluation tools offered images of the surface of the casing-to-cement interface or qualitative averages of cement bonding. The Isolation Scanner is specifically designed to eliminate the ambiguities imposed by dual string eccentralization, contaminated cement or ultra-light or ultra-heavy cements. In addition, the tool can pinpoint areas of casing corrosion, erosion or drilling-induced wear.

The Isolation Scanner measurement builds on the successful UltraSonic Imaging Tool (USIT) platform. It does this by adding a second measurement of flexural attenuation for greatly improved evaluation of lightweight, foamed or contaminated cements. The tool can inspect casing up to 0.79-in. thick for corrosion or wear damage, and can even scan dual casing strings. Most importantly, the tool resolves interpretation ambiguity because it can discriminate between solids and liquids of equal density, a problem that cannot be solved by acoustic impedance or cement-bond/variable density (CBL/VDL) measurements alone.

According to Wright, the new tool benefits operators in four ways:

- Allows evaluation of all the latest cement formulations and eliminates confusion or ambiguity in interpretation.
- Provides complete mapping of possible cement channels at either the casing-cement interface or the cement-formation interface allowing squeeze decisions to be made with confidence.
- Provides visualization and orientation of concentric casing strings, allowing operators to make the best decision on where to set or orient a whipstock, a perforating gun or cased hole formation dynamics tester (CHDT).
- Evaluates integrity of non-cement isolation devices like swellable packers or composite seals.

Evaluates expandable tubulars or sand control media.

Flexural wave attenuation is the key to the Isolation Scanner measurement. When combined with acoustic impedance measurements made by the pulse-echo USIT transducer, a sharp 360° image of the casing, cement and near-wellbore formation volumes results. Using a pitch-catch configuration of one transmitter and two receivers circumferentially scanning the casing, a flexural wave is excited in the primary string. Enough energy "leaks" out to allow evaluation of a secondary casing string or the cement-to-formation interface (Figure 1). The amplitude difference in the flexural wave traveling between near and far receivers is measured to determine signal attenuation.

Combining the attenuation and acoustic impedance measurements eliminates dependency on fluid property measurements, allowing full isolation evaluation with a single logging pass.

Material in the annulus can be solid, liquid or gas (SLG). Unfortunately, to a single measurement the response of these states can have significant overlap (Figure 2). But when the flexural attenuation and acoustic impedance measurements are combined any ambiguity is resolved. Thus lightweight, foamed or contaminated cement can be evaluated and a 360° SLG map of hydraulic isolation can be produced. (Figure 3).

Beyond imaging

When the flexural waveform is imaged beyond the primary casing string and its associated cement sheath, casing eccentricity and proximity to the formation is revealed. A stream of polar plots can be created to produce a "movie" that helps locate the best spots to set and orient a whipstock for window drilling operations, or alternatively, the best spot to set a CHDT. The moving plot can be used to evaluate the proximity of dual casing strings relative to each other as well as to the formation. The existence and orientation of a corkscrewed borehole behind pipe can even be revealed (Figure 4).

The Isolation Scanner can be run in combination with the Sonic Scanner, to give a thorough, in-depth diagnosis of proposed completion zones to enable operators to design completions that deliver maximum productivity over the life of the reservoir. E&P

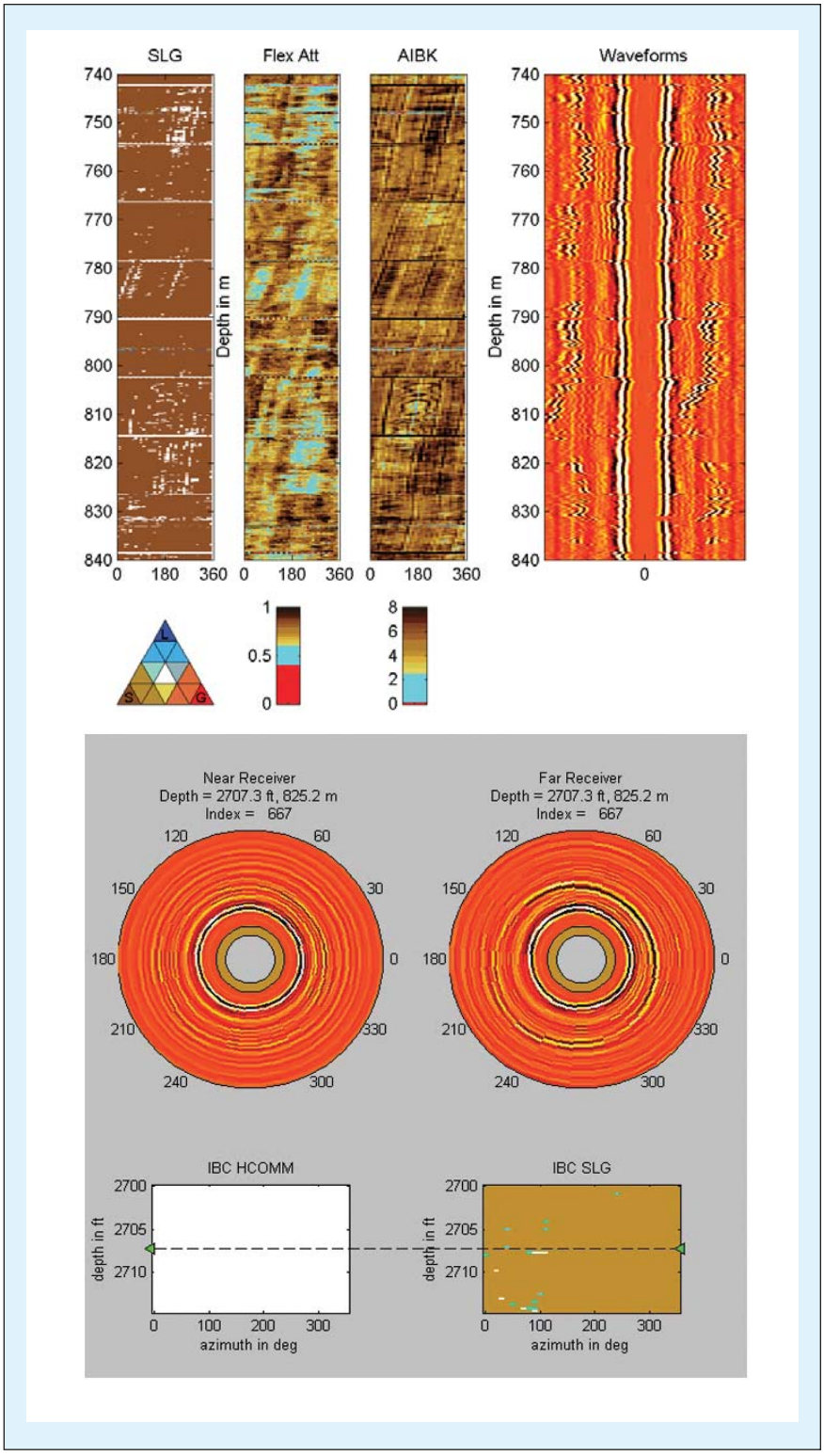

Figure 4. VDL and Polar Plots (orange) map casing/borehole orientation revealing the presence of a corkscrewed borehole. Successive polar plots can be played in streaming video like a movie at the wellsite.