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Geosteering with LWD Azimuthal Sonic Measurements

A. Aki* (Halliburton)

SUMMARY

Broad frequency azimuthal sonic tools provide intriguing geosteering possibilities. They allow us to steer on porosity, lithology, hydrocarbons, or even stress variations.

Sonic tools have multiple depths of investigation and moderate azimuthal resolution. Like resistivity tools, the DOI is a factor of frequency, source-to-receiver spacing, and formation properties (in this case, the velocity).

Compressional or shear velocities can be used for steering. In general, refracted shear will have a slightly shallower DOI than compressional waves, but low frequency dipole shear can have as much as twice the DOI as compressional waves.

Fig. 1 shows a geosteering display using sonic compressional velocities. The real-time data transmitted to surface in this case was a 4-quadrant DTC near image (top track) and a 4-quadrant DTC far image (second track). The bottom track shows the geology model from the pre-well study. The middle three tracks are the expected DTC, resistivity, and gamma ray from the geological modelling. The goal in this example is to remain within the faster yellow formation shown in the geometry plot. In this example, there is not much resistivity contrast between the two beds (24 ohm-meters and 20 ohm-meters), which might make geosteering based on resistivity difficult; there is considerable sonic contrast, however. The yellow formation is 60 us/ft and the green formation is 85 us/ft; consequently, this is an ideal case in which sonic geosteering could complement more familiar resistivity well placement.

In real time, sonic image tracks can be used as follows:

- To “land” the well. Because we are looking for the yellow zone, when the far image begins to detect the yellow formation, we know that we are close and should flatten out our trajectory.
- After the shallow image shows that we are well within the yellow zone (we see yellow from above and below around the tool), we know that we are within the target reservoir.
- If we begin to see the green formation in the far image, we know that we are getting near the edge and must steer away from the edge. For example, around 8,150 ft MD, we see the green formation at the bottom of the sonic image. We know that we must steer upward.