XMAC F1 service provided deep shear wave imaging for unconventional reservoirs

An operator with an unconventional reservoir in the Haynesville Shale wanted help with developing a hydraulic stimulation program. Although one well was performing as expected, there were large production variances between all wells. They contacted Baker Hughes, a GE company (BHGE), to perform a field analysis to provide them with better insight and understanding of their field.

Unconventional shale reservoir evaluation and development presents many challenges. Stimulations required to enhance production and the presence or absence of natural fractures can have a large impact on production results. Fracture variation across a reservoir can be substantial, leading to large production variations even in adjacent wells. Gaining insight about the natural fracture system, both intersecting and around the borehole, can often help determine economic success.

The Cross Multiple Array Acoustilog F1™ service (XMAC F1), from BHGE, provides deep shear wave imaging (DSWI), adding a new dimension to characterizing natural fractures. Traditional methods only analyze the area close to the wellbore, up to 2-4 ft. However, the XMAC F1 service provides information out to 60 ft from the wellbore increasing the investigation area by more than two orders of magnitude.

In this section of the Haynesville Shale, the anisotropy from the cross-dipole analysis is small to non-existent over most of the interval, indicating the formation to be isotropic in nature. There is only a measurable anisotropy of up to 3.5% between x160-x190 ft in a direction just north of east.

The XMAC F1 service results showed a vertical feature over the x195-x240 ft interval at an approximate radial distance of 30 ft from the wellbore. Interpretation of this reflection indicated it is a near vertical fracture striking along the N7SE-S75W axis. This explained the better performance of this particular well compared to the others.

Although the cross-dipole detected a zone with measurable anisotropy, it did not correspond to the interval seen by the XMAC F1 service analysis. There was no measureable anisotropy in the near wellbore region where the deep imaging detected a large 45 ft vertical fracture.

Given the extremely low permeability of the Haynesville Shale, the interval detected by the XMAC F1 service provided the operator with the insight they needed to influence future well placements in their field and reservoir development.

Challenges

- Haynesville unconventional reservoir with high variability in field production where vertical wells were out-producing horizontal wells
- Low permeability shale known to contain natural gas

Results

- Detected large, non-intersecting fractures located 30 ft away from borehole
- Revealed natural fractures within the formation that did not intersect the borehole
- Determined fracture strike direction
- Integrated with existing acoustic fracture analysis without additional logging
- Provided insight of the fracture system for enhanced field and reservoir development
The rose diagram of track 1 displays the fast shear azimuth which is also on the anisotropy map in track 3. Track 2 shows the measured anisotropy, track 5 contains the raw dipole waveform, and tracks 6-9 display the results of the XMAC F1 service.

Depending on whether the tool is below or above the bed, radiated acoustic energy from the cross-dipole transmitters strikes the lower or upper side of the bed and reflects back to the receivers. These reflections enable imaging of the lateral extent of the fracture up to 60 ft from the borehole.