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3D Far-Field Sonic Service Maps Fractures Deep into the Reservoir to Optimize Completion Design

Automated workflow quickly identifies dip and azimuth of fractures beyond the reach of standard logging to improve hydraulic fracturing operations

A 3D far-field sonic service deployed using slim dipole logging conveyance automates time picking and event analysis to quickly derive true dip and azimuth of fractures beyond 20 ft into the reservoir.

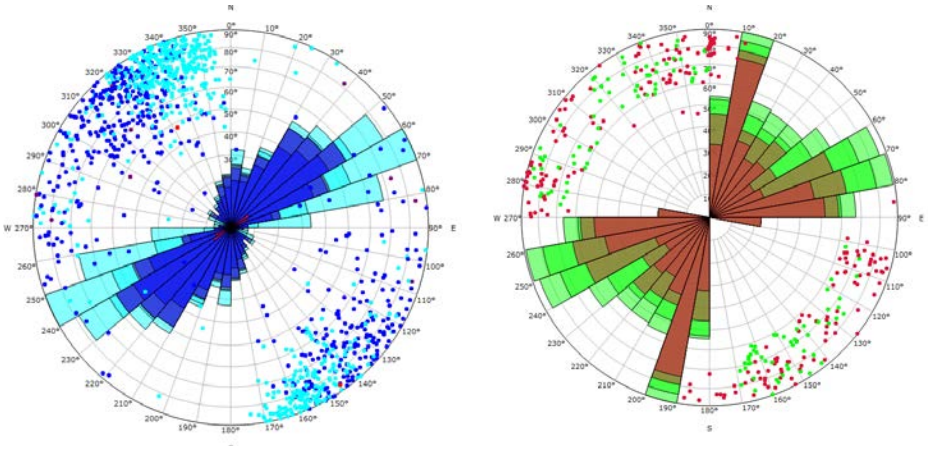
Characterize natural fractures to optimize completion design

A new area in the Midcontinent region contains natural fractures that influence hydraulic fracturing performance. An operator wanted to characterize the occurrence and distribution of these natural fractures along the wellbore into the formation for a 3D understanding of the natural fracture trends to optimize well completion design.

Deploy 3D far-field sonic service to quickly determine dip and azimuth and enhance borehole imaging

To achieve a complete map of fractures at and around the wellbore, Schlumberger recommended a two-pronged approach: acquire standard through-the-bit logging data in oil-based mud to obtain microresistivity images and acquire 3D far-field sonic data using slim dipole logging conveyance for high-quality sonic imaging.

The 3D far-field sonic service workflow automates time picking and event analysis compared with time-intensive, conventional manual determination of reflector dip and azimuth. The service rapidly derives the dip and azimuth of the identified reflectors from the automated event analysis. These events can then be easily integrated with borehole image interpretation constraining the high resolution of near-wellbore reflectors, making them ready to import into 3D geological modeling.

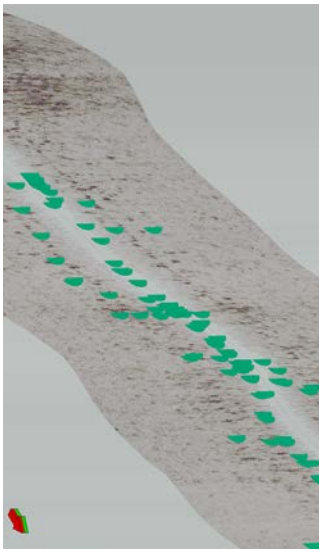


Rose plot of natural fractures from through-the-bit logging (left) and fracture-related events from 3D far-field sonic imaging using slim dipole logging conveyance (right).

Map far-field reservoir fractures to improve hydraulic fracturing operations

The automated 3D far-field sonic processing combined with the migrated sonic image showed natural fractures extending into the formation beyond 20 ft, providing a missing scale of observation between seismic and borehole imaging. Furthermore, fractures could be detected at distance without intersecting the wellbore, and the fracture orientation could be measured.

A notable change in natural fracture distribution near and far into the formation was observed near the well toe. This data enabled the operator to plan hydraulic fracturing in the interval to generate more fracture complexity and near-wellbore friction during the pumping stage.



Migrated image plus events from 3D far-field sonic imaging showing the presence of fractures deep into the formation.

> **"The analysis and interpretation of mechanical properties and the natural fracture characterization completely agreed with the pumping behavior of the different fracture stages during the hydraulic fracturing job."**
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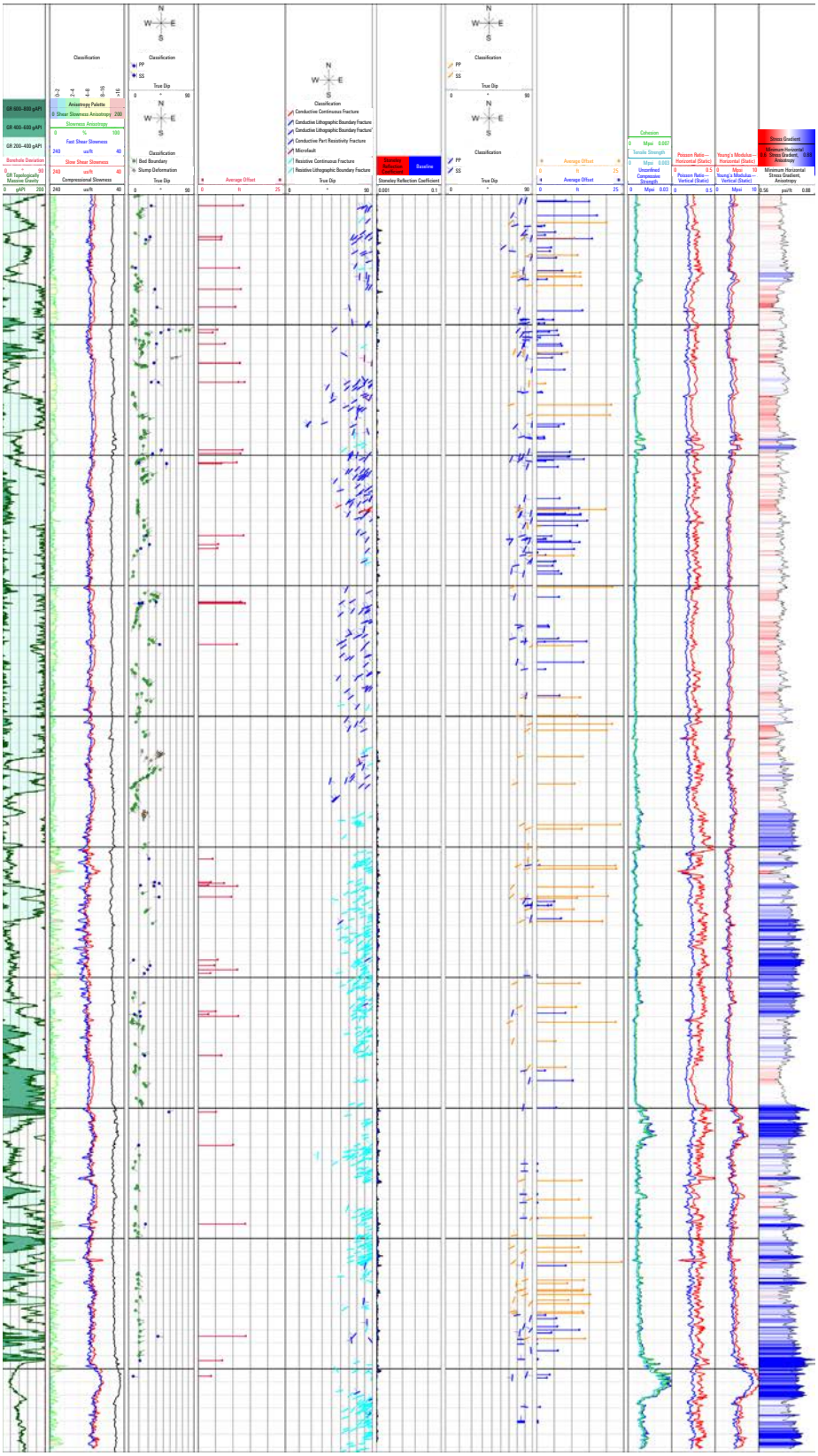
> Supervisor of petrophysics and staff geophysicist

Case study: 3D far-field sonic service maps deep fractures to optimize completion design, Midcontinent, US



Log results from standard through-the-bit logging conveyance (Track 4 and Track 5) and 3D far-field sonic imaging using slim dipole logging conveyance (Track 6 and Track 7). Comparing the events, a notable change is observed in the distribution of the image-interpreted fractures where the classified resistive fracture density increased at the end of the well. This correlates with a change in the mechanical properties (Track 9 and Track 10) and the increase in minimum horizontal stress (Track 11). The 3D far-field sonic imaging results suggest that those fractures are observed at least 20 ft away from the borehole (Track 7). These fractures were used for discrete fracture network (DFN) modeling to optimize the well's completion design.

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