Lateral Characterization and Fracture Optimization Solution with Case Studies

S. Kotov, S. Stolyarov, U. Prasad, and F. Walles. Baker Hughes Inc., Houston, TX, USA

Market surveys (Bloomberg news, March 2016) show that approximately 70% of unconventional wells do not meet their expected production targets, and that approximately 30% of all perforation clusters are not contributing to hydrocarbon production. A review of 125 production logs across multiple shale plays (Welling & Company, SPE 144326) indicate that the best producing wells have at least 80% contributing clusters and the poorest wells have only 30% contributing clusters.

Conversely, ongoing work by leading industry operators has shown a step change in significantly improved hydrocarbon productivity within shorter lateral lengths. This has been attributed to improved targeting using advanced completion approaches with the integration of appropriate data sets, including 3D seismic, and reservoir characterization (specific vertical and lateral logs and core data).

Recent advances in rig-site equipment, technology, and fast data processing has resulted in an improved ability to analyze well cutting's elemental compositions and mineralogy, to better determine mineral facies, and the brittleness (or ductility) contrasts spatially within the length of the laterals. This together with offset acoustic or seismic data can give an indication of stresses and formation breakdown characteristics. The gas hydrocarbons concentrations (C1-C5, & up to C9) from gas data can indicate near-borehole fracture intensity index, reservoir fluid type, productive versus non-productive zones, potential fluid contacts, and reservoir connectivity.

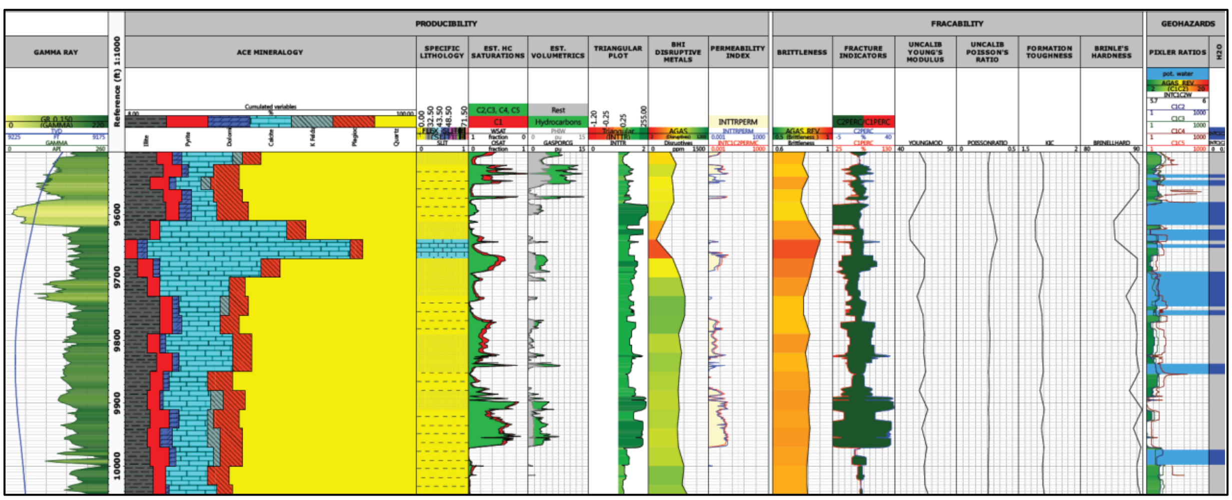

Figure 1: A summary plot of lateral characterization from cuttings and mud-log analysis.

The addition of advanced deep shear wave imaging technology, applied to open or cased hole logging environments, can detect shear impedance boundaries that do not intersect the borehole, i.e., geohazards such as folds, faults, and natural fractures. Combining accompanying acoustic attributes can also be used to develop or complement elastic properties and in-situ stress characteristics determinations.

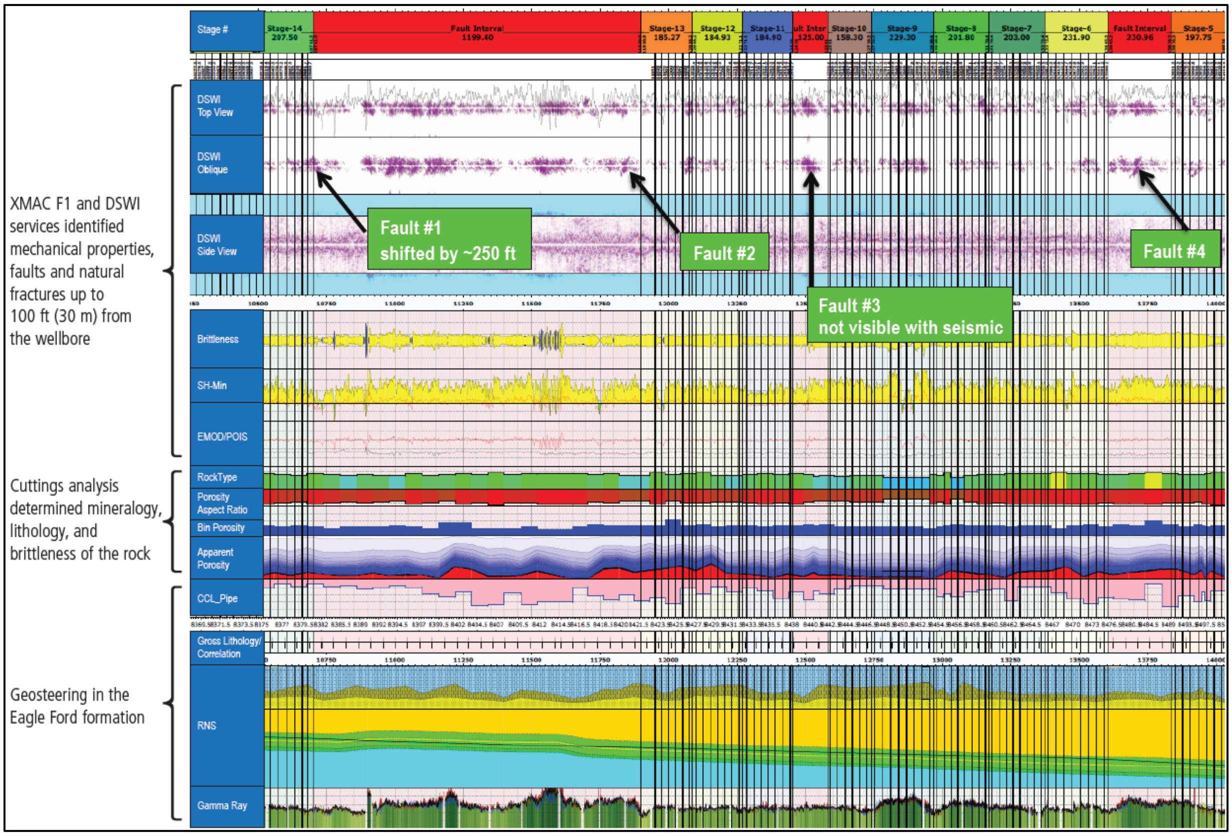

Figure 2: Illustration of the application of deep shear wave imaging technology to detect geo-hazards or faults for avoidance and use of fracture intensity index beyond the borehole vicinity.

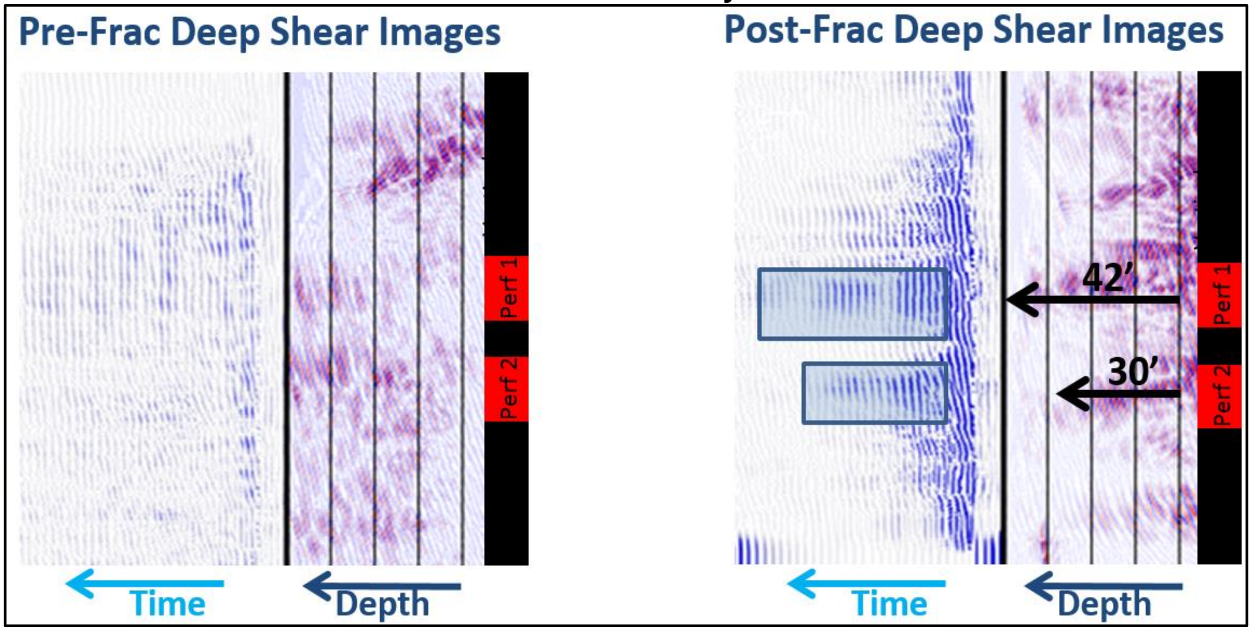

Figure 3: Imaging frac job (height & length) in a vertical well complementary to micro seismic.

Integration of these attributes can improve identification of optimal reservoir property zones with desired hydrocarbon contents, maturity, facies, brittleness, and fracability. This drives improved custom cluster and stage designs for more homogenous distribution of highly complex fractures with the right conductivity along the laterals.

If the stress or brittleness contrast is beyond a threshold limit, suitable diverters can also be utilized and multiple stages can be combined into “super-stages”. This allows better distribution of proppants and fluid systems to maximize individual cluster contributions.

Figure 4: An example showing how the technology used has resulted in $2.5 MM savings.