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Guidelines for the Handling of Natural Fractures and Faults in Hydraulically Stimulated Resource Plays

Ben Stephenson, Kevin Coflin,
Shell Canada Energy
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Abstract

The impact of structural geology on unconventional resource plays has long been a source of uncertainty and debate. Even after many years of drilling, extensive data collection, trials and research, the unconventionals business retains a strong element of empiricism, with poor predictive capability. A classic example of this limitation is our inability to predict the EUR uplift of a hydraulically stimulated well that encounters many natural fractures.

Within Shell, and also widely published, natural fractures were thought to enhance production performance, drawing on well-established relationships in conventional reservoirs. To test this hypothesis, an investigation into production performance across plays in North America was carried out, from Shell and industry data, for the Marcellus, Barnett, Niobrara, Nikanassin, Montney, Duvenay, Haynesville, Bakken and Eagleford formations, all of which exhibit very different structural characteristics.

Our results indicate that the variability in small-scale, natural fracture intensity is not sufficient to be detected in well performance metrics, given the other sub-surface heterogeneity and the intrinsic range in P10:P90 for EUR within any given set of wells. Furthermore, natural connectivity is low. Natural fractures can however, play a role in an enhanced risk of screen-out. The exception is for folded tight-sand plays, where fracture network connectivity is potentially sufficient to provide a measurable enhanced deliverability.

Understanding the impact of seismically-visible, planar, structural features (faults or lineaments) proved to be more problematic, with plays experiencing EUR uplift and impairment. This was explained, with a novel concept classifying faults as “contained” or “uncontained”, contingent on being within a closed system, before and after hydraulic stimulation, or not.

To summarize these observations, guidelines are offered with consideration for:

1) An understanding of how natural fractures and faults affect conventional plays.
2) Production data from Shell’s unconventional assets and industry published material.
3) Hypotheses for the physical processes for how faults and natural fractures affect resource plays during a hydraulic stimulation.
4) A discrimination between discrete structural features based upon scale.