Tight Sandstone Fracture Solutions: The Role of Image Logs and Horizontal Cores in Quantitative Assessment of Critically Stressed Fractures

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Abstract

Fracture characterization is critical for understanding the contribution of fractures to hydrocarbon production in tight sandstone reservoirs. The study focuses on a deep, low permeability reservoir dominated by clean, fine to medium grained massive quartzose sandstones deposited as glacio-marine outwash turbidites of Late Ordovician age. Despite its low permeability, multiple horizontal wells targeting this reservoir produced at high economic rates following fracture stimulation, suggesting some level of fracture contribution. To ground truth this analysis, a horizontal core was acquired to provide valuable insights into the nature of the fractures present. This study presents a novel approach developed to take full advantage of this unique dataset.

The study utilizes horizontal cores, image logs, and geomechanical earth models to analyze and simulate the effects of fracking on critically stressed fractures in a wellbore. The methodology begins with image log analysis across the horizontal section, followed by structural core analysis with the aid of 360 core imaging, which allows for precise fracture interpretation and measurements of fracture orientation. Next, a second round of image log interpretation, involving side-by-side comparison of captured 360 images to ground truth fracture magnitude, orientation, and density. Following this verification process, a comprehensive geomechanical analysis is conducted to investigate the critically stressed fractures present in the system, and predict the degree of change expected by simulating fracking conditions.

Image log analysis identified four prominent conductive (cemented) fracture zones along the horizontal section with a northeast-southwest trend, while only a few partial resistive (open) fractures were observed with an east- northeast to west-southwest orientation. Core analysis confirmed these findings, showing low-angle fractures (30-40°) and high-angle cemented fractures (80-90°) crossing sedimentary structures that dip southeast- northwest. High angle cemented fractures, though reopened during core handling, proved too thin to detect in image logs. In contrast, cored intervals exhibited significantly greater fracture complexity than initially thought based solely on image logs. Geomechanical analysis revealed that over 55% of all conductive (cemented) fractures encountered across the wellbore were in a critically stressed state, with high-angle fractures comprising the majority of these fractures (70%). Simulation of fracking conditions indicated a strong likelihood of high-angle fractures experiencing reactivation, as evidenced by a 40% increase in the number of critically stressed fractures. In comparison, low-angle fractures display limited potential for reactivation, with a modest 10% increase.

The study presented a novel approach for comprehensive fracture characterization in tight reservoirs using a combination of cores, image logs, and mechanical earth models. The analysis revealed a complex fracture network, where high-angle fractures are more susceptible to reactivation after fracking compared to low-angle fractures. Thin, high-angle fractures observed only in cores share a similar susceptibility,

indicating a far more intricate fracture network than initially thought. Critically stressed fractures are believed to contribute significantly to production, highlighting the need to accurately assess their potential impact to the overall production of tight reservoirs.