Using SMTI Topology with Dynamic Parameter Analysis to Characterize Crack Connectivity Related to Flow and Production along Wellbores in the Meramec Formation

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ABSTRACT

The understanding that flow and production in unconventional resource plays is controlled by our ability to establish a series of interconnected cracks or fractures to access the hydrocarbon away from the well. This issue has led to attempts to characterize the crack network through the use of microseismicity recorded during stimulations. By utilizing well-established approaches in earthquake seismology (Seismic Moment Tensor Inversion – SMTI, Deformation State Analysis – DSA, and Stress Inversion), we can examine microseismic signals and obtain information about individual failures such as fracture orientation, the complexity of the rupture process (mechanism, slip, surface roughness), the relative dimensions of rupture or fracture surface, and the strain-stress conditions that results in these failures.

To effectively assess the potential of the established crack network for flow and production we have adapted scanline and topological approaches to use with microseismic events. Topology provides an assessment of connectivity of the individual fractures within the network. Additionally, we can examine the collective behavior of microseismic occurrences (Dynamic Parameter Analysis – DPA), where it is suggested that microseismic events do not occur in isolation but have a spatial and temporal context. By examining microseismicty in this manner, we gain insight into the underlying stress, fracture and deformation state of the rock mass. As such, combining DPA with topology allows for an interpretive understanding of rock, and specifically crack behavior, in relation to regions with an effective permeability enhancement leading to production.

In this study we apply these approaches to an injection program in the Meramec formation in Oklahoma. Here, we were able to uniquely determine the crack distribution for different treatment styles, establish the effect of proppant size, and related the observed crack behavior to changes in rock deformability, stress transfer and stress state. Combined, these data allow us to define the volume of inter-connected fractures leading to an enhanced zone of permeability surrounding the treatment well. Overall, we suggest that these integrated approaches provide a viable methodology for assessing and optimizing completion programs in unconventional plays.