Calgary • Canada • May 13-17 2019

Close Encounters in the 3rd Dimension: Using Diagnostic Fracture Injection Tests (DFITs) from the Alberta Duvernay Shale Formation to Quantify Simultaneous Horizontal- & Vertical-Plane Hydraulic Fracture Growth

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Summary

This paper will benefit engineers and geoscientists interested in creating representative hydraulic fracture simulation models and optimizing commercial-scale fracture treatments. The paper focuses on the emerging Duvernay shale formation in Alberta, Canada. Well fracturing pressures are often significantly higher than the Overburden (OB, lithostatic) pressure. Pressures above OB likely create horizontal (hz) bedding plane fracture components since sedimentary rocks are almost always weaker along bedding planes. Most fracture design simulators do not account for the simultaneous existence of multi-plane fractures (Figure 1). Therefore, scaled treatment designs for optimizing fluids, proppant schedules and production performance may be flawed. A key question is: What proportion of the overall fracture volume do horizontal-plane features take? The answer can be sought using the Pressure Transient Analysis (PTA) workflow for Diagnostic Fracture Injection Tests (DFITs) described by Bachman et al (2012, 2015) combined with simple PKN and GDK fracture models to represent the hz and vertical plane fracture components.

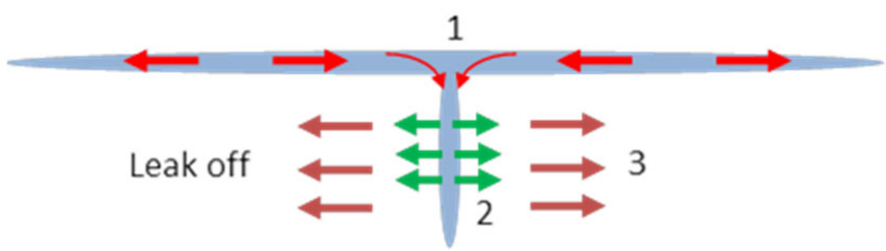

Figure 1: Simplified Representation of Leak-off from Concurrent Horizontal & Vertical Plane fractures with ISIP>OB

DFIT analysis techniques and interpretation are hotly debated topics of late. The authors believe a portion of the gap in the understanding of how hydraulic fractures behave is a result of assuming fracture components are fully, or dominantly, vertical. Analysts often interpret high fracturing pressures as tortuosity or near-well friction. However, during the fall-off period after pumping a DFIT, pressures above OB can persist for up to 20 minutes after pump shut-down. Analysis of these tests often exhibit early-time radial flow signatures which are coincident with the OB gradient of ~22kPa/m (1psi/ft) also indicative of hz plane fractures. In Nicholson et al 2017 four field DFIT examples were presented showing strong evidence of hz plane fractures in various depths and formations found in the Western Canadian Sedimentary Basin.

In the current paper DFIT PTA analysis is applied to two West Shale Basin Duvernay datasets. A physical model is presented (Figure 1) that incorporates the in-situ stress regime, rock fabric, and pore pressure and that allows history matching of DFIT leak-off and closure behavior for fractures above OB pressure. Simple calculations are provided to estimate the volume and dimensions of these same components for a small volume, single viscosity, no-proppant injection DFIT. This unique approach provides a valuable calibration point for building more advanced simulation models.