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Utilization of Real Time Microseismic Monitoring and Hydraulic Fracture Diversion Technology in the Completion of Barnett Shale Horizontal Wells

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Abstract

It is now well documented that hydraulically fractured horizontal wells are effective at stimulating shale reservoirs. Most commercial shale wells utilize cement or open hole packers to achieve some form of annular isolation. With annular isolation now commonly accepted, the general evolution of these completions has been to stimulate ever shorter sections of the lateral with multiple perforation clusters placed closely together. The objective being to create closely spaced fractures, thereby increasing the reservoir contact area that more effectively imposes a pressure drawdown within the ultra-low permeability reservoir, resulting in a higher recovery factor.

The heterogeneous nature of unconventional shale reservoirs makes achieving a complex, closely spaced fracture network problematic. Frequently, geologic structure impacts the created fracture network to such a degree that fluid entry points into the reservoir are of secondary importance. Horizontal well evaluation can be utilized to optimize perforation placement and fracture staging for near-wellbore fracture geometry generation. This has proven to improve well performance. An additional productivity step can be achieved if the far field fracture geometry can be influenced by techniques other than perforation and fracture staging, especially if this technique can be applied in real time during the stimulation treatment.

One method that has been successful at altering the created hydraulic fracture geometry is real time microseismic fracture mapping coupled with fracture diversion packages incorporated into the fracturing treatment. Evaluating microseismic events in real time allows one to determine the need to change the fracture geometry being generated. The introduction of diversion packages to achieve this fracture geometry alteration can immediately be evaluated for effectiveness via the microseismic activity. This feedback allows the completions engineer to appropriately use these diversion packages so that effective stimulation along the whole lateral can be achieved.

Examples of the use of real time microseismic fracture mapping and fracture diversion packages are shown from the Ft. Worth Basin Barnett Shale formation. Both initial well completions and recompletions are shown. The importance of integrating well, geologic, log, and seismic information, is emphasized so that decisions can be made effectively in real time using the microseismic activity from the treatments. These examples demonstrate that hydraulic fracture geometries can be influenced by the introduction of these diversion packages. Resulting well productivity and fracture pressure responses validate the effectiveness of this real time diversion and evaluation process.

Geologic Setting

The Barnett shale is located within the Forth Worth basin and varies in thickness from 50 ft to the southwest near the Llano Uplift to approaching 1,000 ft near the Muenster Arch in the northeast corner of the basin where it reaches a depth of 10,000 ft. It is a Mississippian-age marine shelf deposit that unconformably lies on the Ordovician-age Viola Limestone/Ellenberger group and is conformably overlain by the Pennsylvanian-age Marble Falls Limestone. In much of the "Core Area" in the northeastern counties of Denton, Wise and Tarrant, the Barnett contains a separate Upper Barnett interval, isolated from the Barnett by the Forestburg Lime. Permeabilities on the order of nanodarcies with gas filled porosities of approximately 3% to 5%. The Barnett is its own source rock and is abnormally pressured in the "Core Area"[1], but the reservoir to the south and