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Optimizing the Completion of a Multilayer Cotton Valley Sand Using Hydraulic-Fracture Monitoring and Integrated Engineering

Jason Baihly, Schlumberger; Andrew Coolidge and Steven Dutcher, Devon; and Ruben Villarreal, Mike Craven, Keith Brook, and Joël H. Le Calvez, Schlumberger

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Abstract

Microseismic hydraulic fracture monitoring is having a major impact in how wells are being completed in tight sand reservoirs. This existing technology is being utilized in new and innovative ways to provide operators a clearer picture of the fracture development. This information can be combined with other fracture diagnostic techniques, and along with sound engineering practices, can have a profound impact on how wells are completed.

This paper discusses the completion design methodology, execution, and results from two offset wells. The first well was completed with a two stage hydraulic fracture treatment while the successive offset was completed via a single-stage fracture treatment. The evaluation tools utilized to determine the resultant fracture attributes include microseismic hydraulic fracture monitoring, hydraulic fracture surface treating pressure-history matching, and tracer and production log interpretation in addition to production analysis. The results from each well are compared and contrasted, and a plan for potential future completions is discussed.

The microseismic event growth and fracture treating pressures over time revealed how the fracture propagated. In the first well the microseismic and treating pressure results of the first stage showed height growth into the proposed zone to be targeted by the second stage treatment. Lessons learned from the first subject well were then incorporated into the completion design of the offset well to optimize its overall completion efficiency. The second well was hydraulically fracture stimulated with a single stage treatment. The completion design changes incorporated in the second well showed some positive effects on the microseismic fracture geometry and resultant production.

An integrated analysis approach can provide an improved understanding of the fracture behavior within a field. This improved knowledge of the fracture system can lead to optimum completion designs and well spacing. These changes can then themselves be evaluated with the aforementioned tools to determine their level of success. This continuous improvement process can be repeated for future fieldwide well completion designs in order to achieve an optimum fracture system within the targeted intervals.

Introduction

The Cotton Valley sand is an abundant consolidated sand formation located throughout East Texas, North Louisiana, and South Arkansas. The Cotton Valley sand was formed during the late Jurassic period.[1] The depositional environment was relatively shallow water regions that left sediments forming barrier bars and lagoonal muds. Storm cuts and organic burrowing also characterize the depositional environment.[2] The thickness of the Cotton Valley sand can grow as large as 1,500 ft.[1] Changes in stream positions and shorelines due to sea level fluctuations caused a large variation in the thickness and aerial extent.[2] Sandstones and shales are intermixed throughout the Cotton Valley group resulting in a highly laminated formation. Sand layers have contiguous thicknesses of only a few inches up to 15 ft. Very fine grained sandstones, siltstones, shales, and limestones comprise the majority of the rock types found in the Cotton Valley sand interval. Calcite cementation, quartz overgrowth and overburden pressure have greatly reduced the permeability and porosity of the sand layers. Sand porosities range from 2% to 12% with permeabilites <0.01 md.[3]

Wells in the Cotton Valley sand have to be hydraulically fractured to produce gas economically because of such low permeability. Well spacing has been reduced to drain the reservoir effectively, and is as low as 20 acres in some fields. Over 14,500 wells have been drilled and completed in the Cotton Valley sand as a result of small drainage spacing and the large aerial extent.[4] Fracture treatments in the early 80’s were large jobs consisting of 10,000 bbl or more of crosslinked gel and as much as 2,500,000 lb of 20/40 sand at concentrations as high as 8 PPA.[5] In the 90’s the job sizes were reduced considerably and treated water (slickwater) along with crosslinked gels were common with 1 to 5 PPA proppant concentrations.[6] Today, a wide range of fracturing designs exist in the Cotton Valley sand. Some operators use treated water, some foam, others crosslinked gel, a few use synthetic viscous fluids, and