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Engineering Applications of Microseismic Data

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Abstract

Microseismic monitoring can be used for both completions engineering and reservoir engineering applications. Examples from a number of North American shale formations, including the Eagle Ford and the Marcellus, will illustrate how to use microseismic pointsets to optimize field development and wellbore spacing, the completion design of the wells, as well as the treatment schedule, resulting in significantly shortened appraisal timelines and acceleration of the learning process in these challenging reservoirs. Distinguishing between the total stimulated rock volume (SRV), where microseismic activity was observed, and the part of the SRV that contains proppant filled fractures (as illustrated in Figure 1), and will therefore be productive in the long term, allows for definition of a drainage volume and calculate a system permeability that can be used to predict production. In order to model the discrete fracture network (DFN) resulting from the treatment, event locations, and their associated source mechanisms, are used to calculate the geometry of the individual fractures (length, height, aperture) as well as their orientation in space resulting in a DFN that is calibrated on microseismic measurements (event magnitude, source mechanisms), the rock properties of the treated reservoir and the injected fluid volume. Distance-based material balance proppant filling on a stage-by-stage basis produces a propped half-length which can be used to determine the optimum wellbore spacing. Additional integration of pump data and the treatment schedule can help with optimizing stage length and cluster spacing in order to enhance complexity and connectivity of the created fracture network resulting in more uniform drainage of the reservoir along the wellbore. Based on the DFN and the SRV, a permeability tensor scalar can be calculated for the rock volume containing microseismic activity quantifying the relative permeability enhancement due to the hydraulic stimulation in every grid cell taking into account the total number of fractures in an individual grid cell as well as their orientation and geometry. In addition to the permeability scalar a system or bulk permeability can be obtained from an evaluation of the spatio-temporal dynamics of the microseismic events, quantifying the absolute ability to deliver hydrocarbons into the hydraulic fracture system and through the fracture network back to the wellbore. Validating observations and predictions by looking at multi-year production data showed a decreasing correlation with the total SRV over time while the correlation with the SRV containing proppant filled fractures increased illustrating the definition of a long-term drainage volume defined by a proppant filled fracture network. The excellent correlation between calculated system permeability and production logs on a stage-by-stage basis gives confidence that microseismic data can be used to optimize wellbore completions, help define different drainage volumes at different times in the life cycle of a well, and ultimately predict production.

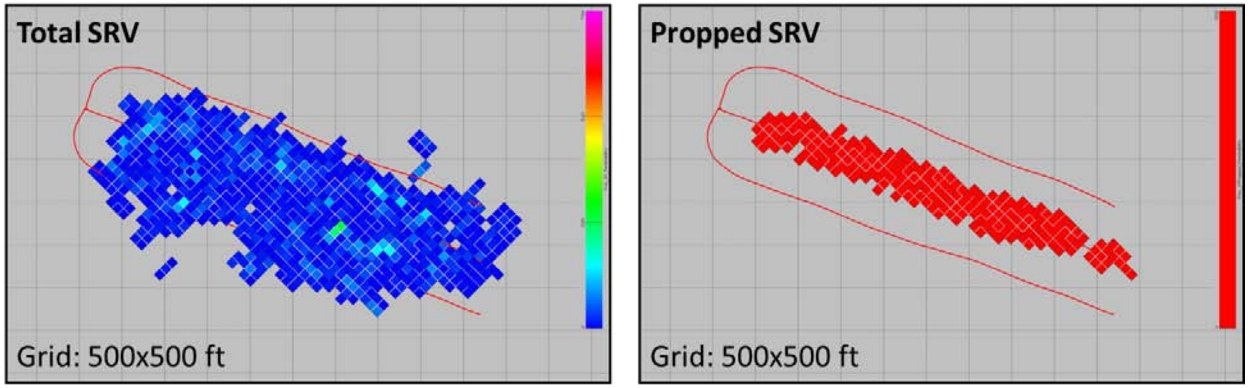

Figure 1: Total Stimulated Rock Volume (SRV) compared to SRV containing proppant filled fractures for a Marcellus well.