9/27/2017; 11:15AM

Unlocking the potential of microseismic monitoring for hydraulically fractured tight reservoirs: A Perspective View

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Traditional estimates of producing volumes have leaned heavily on rate-transient analysis (RTA) of production decline curves to understand the producing volume. The methodologies of fitting these curves typically require months of collected production data. Therefore, any data that is able to achieve confident estimates of productive volume on a much shorter timescale with increased confidence becomes inherently valuable.

One such data stream that has received attention in terms of establishing estimates of producing volume on a much shorter time scale are the microseismic emissions that are recorded during hydraulic stimulations. Microseismic monitoring has become a well-established method as applied to monitoring of hydraulically stimulated wells. Since its commercial inception 20 years ago, the technology has steadily evolved to provide more meaningful answers to operators in terms answering baseline questions on fracture geometry, investigating to what extent different injection parameters may influence the stimulation, and revealing the response to changes in geology.

However, early estimates of producing volume under the assumption that each microseismic event contributes equally to the overall production of the reservoir consistently has resulted in overestimates of productive volume consequently causing some to question the value of the technology. These simplistic methodologies are often being driven by a very cursory analysis of the microseismicity, where the focus is on obtaining a location in the reservoir and a relative size estimate. There is much more information available in the microseismic data stream than is typically brought to bear to answer these problems.

A number of advancements in understanding the microseismic response are allowing for data-driven decisions to be made from the results of monitoring. By using of advanced processing to reconstruct the failure mechanisms (Seismic Moment Tensor Inversion or SMTI), models of the discrete crack network (DCN) can be constructed based on the microseismic response offering very tight constraints to be placed on the geomechanics of the fracture development. Furthermore, the idea that microseismic events do not occur in isolation but rather they behave in a collective manner resulting from the underlying stress-strain state, crack state and rock mass properties themselves provides further insights into the development of productive volumes (referred to as Dynamic Parameter Analysis or DPA). Inherently, without explicit accounting of the crack behaviour within a volume we can through DPA identify the resultant deformability associate with the developed crack network leading to productive volume enhancement and the percolation of hydrocarbons back to the treatment well.

In this study, by utilizing DPA concepts, we examine the possibility DPA can provide constraints on RTA analyses and that with history matching, as a proof of concept proxy, we can provide near real-time feedback (predictive relationships) on the effectiveness of the frac design rather than waiting for production data to be collected. We further examine the opportunity to define distinct volumes associated with different stimulations that can be used in further optimal field development of a reservoir and thereby provide a clearer estimate of the attainable reserves (i.e. a calibration point for reserve estimation). This also includes an in-depth examination of stage length variability and its implications on well spacing and pad design and the resulting well performance.