Lessons Learnt from Microseismic Surveys

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Abstract

Objectives
Microseismic monitoring has become increasingly important in hydraulic fracturing operations due to its ability to map the spatial extension of the induced fractures. Distinct microseismic responses can be attributed to a multitude of potential drivers, like the geological setting, the stimulation design or the pre-existing fracture system. This study aims to provide a comparative analysis between two microseismic acquisitions, highlighting their distinct findings and possible attributing factors in terms of acquisition, stimulation and fracture geometry.

Method
In each microseismic acquisition, two lateral wells were monitored using a horizontal well drilled in the middle to ensure adequate detectability (Figure 1). Key characteristics for each acquisition, including microseismic cloud shape, fracture geometry, off-stage clustering, cloud overlap and event density, are quantitatively assessed. The integration of well-log information, seismic-based discontinuity attribute maps and injection data is performed to investigate the existing natural fracture network and identify potential zones of weakness along the lateral drain, as well as to analyze the spatiotemporal evolution of the microseismic events during three stimulation periods: initial injection, stable injection and post shut-in period.

Results
The microseismic activity observed in both surveys suggests that there is an even distribution of clouds with fractures developing more prominently in the direction of the monitored well. The first acquisition shows a classical planar cloud orientation and an overall consistent extension between the two stimulated wells. The latter acquisition, exhibits anomalous behaviors, including inconsistent orientation, variable event count within the same well and between the two stimulated wells, the occurrence of isolated events, tight grouping, diffused distribution, microseismic cloud overlap and clusters that are localized further away from the fracturing port.

Data integration with the second microseismic acquisition indicates a possible reactivation of macroscale pre-existing natural fractures influencing the orientation and intensity of the microseismic response, particularly during the initial pumping and post shut-in phases. Evidence of stress shadowing was observed in the first fractured well, a geomechanical phenomenon which limits vertical propagation of several stages, and causing heterogeneity in the microseismic cloud size.

Novelty
This study extends the analysis of microseismic data beyond the standard workflow of locating the microseismic events. The careful examination of the evolution of the induced fractures, the geometry of the cloud, the quantitative evaluation of
two datasets acquired in the same field can greatly enhance the understanding of the intricate geometric patterns caused by hydraulic fracturing, being a response to geology, treatment parameters and the dynamics of the interaction between hydraulic and natural fractures.

Figure 1: 3D illustration of the microseismicity captured in two multilateral well pads during multistage hydraulic fracturing activities.