Title: Source Parameters Of Repeating Microseismic Events During Hydraulic Fracturing Operations

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Abstract:

Objectives/Scope: A complete microseismic event catalog with accurate source parameters can help to better understand the temporal and spatial variation of stress during hydraulic fracturing operations. We detect, locate and characterize repeating microseismic events by determining their source parameters such as magnitude, stress drop and rupture size.

Methods, Procedures, Process: The continuous microseismic data recorded by one borehole array during a hydraulic injection process is analyzed. With an existing microseismic event catalog, we first re-calculate accurate moment magnitude and stress drop using estimated source spectra for all events. In addition we detect and locate smaller events that show only clear S-wave arrivals using a template matching and waveforms cross-correlation technique to identify repeating microseismic activity. The template waveforms are obtained by stacking similar waveforms from repeating microseismic families. Once we detect a new event, their S-wave arrival times and potentially the P-wave arrivals, we relocate the events using double-difference algorithms.

Results, Observations, Conclusions: Among the ~1300 re-computed events, the moment magnitude calculated from the P- and S-waves spectra analysis ranges between MW −1 and −2. These events are located within a 700m and 200m wide area in the horizontal dimension and 250m ranges in depth. Our results indicate a fault radius of the order of 2 to 5 meters and fault slip between 10^(−6) to 10^(−4) meters around the fracturing region. The maximum stress drop of P-wave occurs in the deeper layer with the highest value of 1.4MPa while the minimum stress drop took place in the shallower layers with the value as small as ~0.03MPa. The average stress drop for all events is ~0.2MPa. Our observations suggest a significant magnitude dependence of stress drop, with small events having significantly smaller stress drops than larger ones.

Novel/Additive Information: We can detect and locate low signal-to-noise ratio events as the repeating microseismic events by using matching filter technique. These source parameter estimates are key for better understanding the relationship between hydraulic fracturing and microseismic activity.

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