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The Matched Filtering Algorithm (MFA): Extending the potential for detection and location of microseismic events. Hints for induced seismicity hazard?

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Microseismic monitoring is usually achieved by installation of receivers at the surface or in a wellbore, providing an effective technology to analyze brittle deformation processes associated with fracture development. In practice, downhole microseismic monitoring is often undertaken using an array of geophones within a single monitor well. For this acquisition geometry, event hypocentres are typically computed by conventional techniques, by first picking P- and S-wave arrival times. Although some automation of this process can be achieved, it nevertheless requires a significant level of user interaction, and is prone to missing events for which only a single-phase (e.g., the S-wave) is readily discernible.

We describe a novel Matched Filtering Algorithm (MFA) for detecting and analyzing microseismic events recorded by downhole monitoring of hydraulic fracturing. This method requires a set of well-located template ('parent') events, and selected on the basis of high signal-to-noise (S/N) ratio. Detection and extraction of additional, 'child', events are based on stacked, multi-channel cross-correlation of the continuous waveform data, using the parent events as reference signals. The location of a child event relative to its parent is determined by rotation of the multi-component waveforms into the ray-centered co-ordinates of the parent and maximizing the energy of the stacked amplitude envelope within a search volume around the parent's hypocentre. After correction for geometrical spreading and attenuation, our method estimates the relative magnitude of the child event, using the ratio of stacked envelope peak with respect to its parent,

The efficacy of the MFA method has been demonstrated in a real-data example, using microseismic monitoring data from 4 stages of an open-hole slickwater hydraulic fracture treatment in western Canada. A sparse set of parents (in this case, 4.6% of the originally located events) yields a significant (more than four-fold) increase in the number of child events detected and located, in comparison to the original commercial catalog.
Further analysis of the new MFA catalog suggests that this approach leads to more robust interpretation of the induced microseismicity, while shedding light into dynamic rupture processes, based on the average temporal (foreshock-aftershock) relationship of child events to parents.

The MFA approach perhaps used in combination with other techniques for estimating the Stimulated Reservoir Volume (SRV) can hold promise for interpretation of induced seismicity processes in an oil-gas reservoir. Improving in location estimate may help to "illuminate" fracture networks and/or buried faults, with application to mitigation strategies.