Passive seismic methods for hydraulic fracture monitoring:
Resolving fracture networks, slow slip and earthquake nucleation processes

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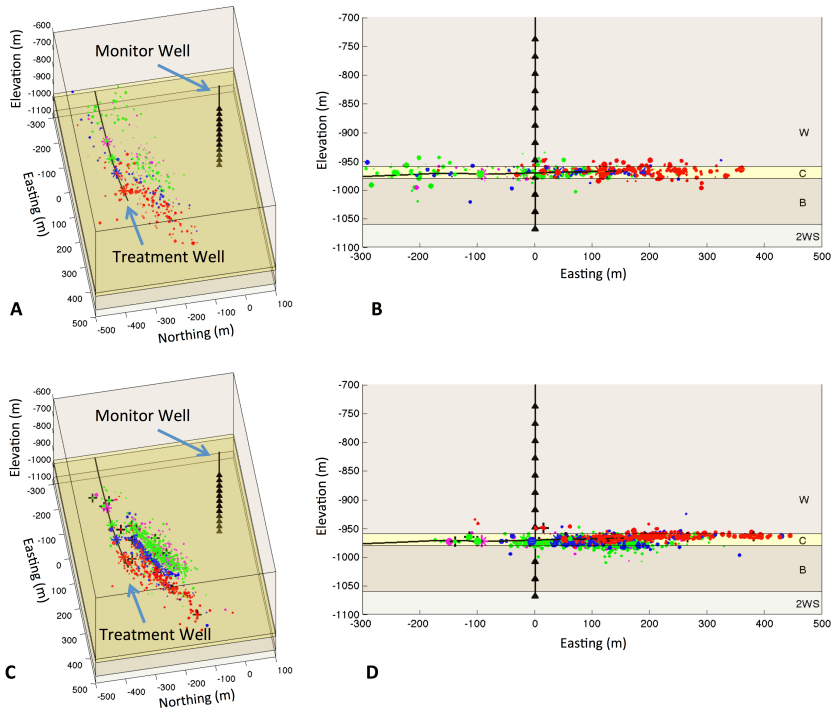
Hydraulic fracturing or stimulation methods are widely used for enhancing the permeability of unconventional hydrocarbon or geothermal reservoirs. Passive seismic monitoring, using surface or downhole sensor arrays, is sometimes used to monitor the distribution and characteristics of induced (micro)earthquakes. Within the process zone near the injection site, much of the recorded microseismicity is inferred to arise from activation of slip or tensile opening along pre-existing fractures, due to the effects of both pore pressure and stress perturbations. There is ongoing debate about whether this is also accompanied by slow-slip rupture processes, analogous to some fault systems. In rare cases, basement faults have been activated by hydraulic fracturing, leading to induced earthquakes. The application of template based-methods for event detection and location are effective for illuminating fracture networks and understanding the deformation processes induced by the hydraulic stimulation. Similar techniques show promise for resolving small-scale nucleation processes associated with fault activation.



Perspective views (left) and depth sections (right) showing microseismicity from the first 4 treatment stages of hydraulic fracturing in a low-permeability reservoir (Eaton and Caffagni, 2015, First Break, *33*(7), 49-55). Panels A and B show the results from initial commercial processing; C,D show results using a matched filtering method.

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