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Rupture Propagation Imaging of Fluid Induced Events at the Basel EGS Project

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The analysis of rupture properties using rupture propagation imaging techniques is a fast developing field of research in global seismology. Usually rupture fronts of large to megathrust earthquakes are subject of recent studies, like e.g. the 2004 Sumatra-Andaman earthquake or the 2011 Tohoku, Japan earthquake. The back projection technique is the most prominent technique in this field. Here the seismograms recorded at an array or at a seismic network are back shifted to a grid of possible source locations via a special stacking procedure. This can provide information on the energy release and energy distribution of the rupture which then can be used to find estimates of event properties like location, rupture direction, rupture speed or length. The procedure is fast and direct and it only relies on a reasonable velocity model. Thus it is a good way to rapidly estimate the rupture properties and it can be used to confirm independently achieved event information.

We adopted the back projection technique and put it in a microseismic context. We demonstrated its usage for multiple synthetic ruptures within a reservoir model of microseismic scale in earlier works. Our motivation hereby is the occurrence of relatively large, induced seismic events at a number of stimulated geothermal reservoirs or waste disposal sites, having magnitudes $M_L \geq 3.4$ and yielding rupture lengths of several hundred meters. We use the configuration of the seismic network and reservoir properties of the Basel Geothermal Site to build a synthetic model of a rupture by modeling the wave field of multiple spatio-temporal separated single sources using Finite-Difference modeling.

The focus of this work is the application of the Back Projection technique and the demonstration of its feasibility to retrieve the rupture properties of real fluid induced events. We take four microseismic events with magnitudes from M_L 3.1 to 3.4 and reconstruct source parameters like location, orientation and length. By comparison with our synthetic results as well as independent localization studies and source mechanism studies in this area we can show, that the obtained results are reasonable and that the application of back projection imaging is not only possible for microseismic datasets of respective quality, but that it provides important additional insights in the rupture process.