Time-lapse monitoring of fractured rock response to hydraulic stimulation using pressure tomography

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Hydraulic stimulation using high-pressure fluid injection has become the common technique for rock mass treatment in various industrial applications such as oil & gas, mining and enhanced geothermal system (EGS) development. Hydraulic stimulation is associated with creation of new fractures or dilation of existing fractures that could alter the flow regime in the stimulated reservoir. In this context, it would be beneficial to understand the dynamic response of the discrete fracture network (DFN) to the stimulation activities rather than comparison between the changes in injectivity and/or transmissivity.

In this work, a 2-D fully coupled hydro-mechanical model is developed to simulate the dynamic response of a fractured reservoir to hydraulic stimulation. The model calculates stresses, fracture fluid pressure and flow inside the fractures, and modifies the physical properties of the individual fractures given these values. All these alterations will be calculated and applied after each simulation timestep. The results of this synthetic modelling will be used to test the time-lapse pressure tomography approach.

Pressure tomography will be simulated at multiple timesteps, to capture the hydraulically active fractures within the system. The used tomographic interpretation will be based on the transdimensional DFN inversion, where model parametrisation could change over time. With this methodology we can model the newly opened fractures by the stimulation.

The time-lapse inversion will use the result of the previous timestep as the initial solution for improved efficiency. We test the proposed methodology on outcrop based synthetic 2-D DFN models. The results could capture the changes of permeability (i.e. aperture) as a direct response to hydraulic stimulation.