Numerical investigation of hydraulic stimulation and related induced seismicity in Pohang fractured geothermal reservoir

Márton Pál Farkas[1,2] *, Hannes Hofmann[2], Jeoung Seok Yoon[3], Günter Zimmermann[2], Arno Zang[3], Ove Stephansson[3]

[1]Institute of Earth and Environmental Science, University of Potsdam, Karl-Liebknecht-Straße 24/25, Potsdam 14476, Germany
[2]Section 6.2 Geothermal Energy Systems, GFZ - German Research Centre for Geosciences, Telegrafenberg, Potsdam 14473, Germany
[3]Section 2.6 Seismic Hazard and Stress Field, GFZ - German Research Centre for Geosciences, Telegrafenberg, Potsdam 14473, Germany

* Presenting author. [farkas@gfz-potsdam.de]

Abstract

Understanding processes that control induced seismicity during fluid injection in naturally fractured geothermal reservoirs is in focus of recent research projects about Enhanced Geothermal Systems (EGS). In this study we investigate different flow rate controlled stimulation techniques such as continuous, step rate and cyclic in terms of development for a soft stimulation method that enables generating higher permeability and less induced seismicity for the EGS project at Pohang, Korea. We use two different numerical methods to investigate coupled processes in detail. The discrete element software Particle Flow Code (PFC) enables simulating hydro-mechanically coupled fluid flow in crystalline rock with low porosity and pre-existing fractures (represented by the smooth joint contact model) and associated microseismicity in two dimensions. The finite element code FRACMAN uses the Discrete Fracture Network (DFN) approach that combines continuum and discontinuum geomechanics. It enables to study thermal-hydro-mechanical processes and investigating main characteristics of induced seismicity in three dimensions as well. Its dual porosity/dual permeability fluid flow algorithm allows incorporating poro/thermal-elasticity in the model.

By using continuum and discontinuum-based numerical models one can get more insight into the complex processes governing the stimulation of fractured rock masses. The models provide spatial and temporal evolution of induced seismic events (with an emphasis on occurrence of post-shut-in magnitude events), moment magnitudes and focal mechanism in relation to fluid pressure distribution, and fracturing mechanism. Besides computational techniques the modelling study is also supported by results of laboratory true triaxial tests on crystalline rock samples and in situ tests both with detection of acoustic emission (AE) events and seismicity at Äspö Hard Rock Laboratory. We conclude that the two modeling codes are capable of simulating induced seismicity phenomena in Enhanced Geothermal System from cyclic fluid injection in deep fractured reservoirs might be considered as an efficient technique to prevent larger magnitude induced events.