Modelling Reservoir Stimulation in Enhanced Geothermal Systems

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Abstract

Fluid injection in deep wells is a basic procedure in geothermal permeability enhancement. We have recently presented a numerical procedure to describe its potential to induce seismicity in literature. This is based on the simulation of the thermodynamic evolution of the system where fluids are injected. The retrieved changes of Pressure and Temperature are subsequently considered as sources of incremental stress and strain changes, using the elastic model from COMSOL Multiphysics®, which are then converted to Coulomb stress changes on favoured faults, taking into account also the background regional stress.

In this work, we first upgrade this kind of procedure to evaluate the permeability enhancement obtained in the stimulation process. Actually, in fractured porous media subjected to external loads, the stress changes affect the rock permeabilities. Assuming a conceptual model linking induced strain and permeability changes, we can estimate the permeability changes induced during the stimulation process. In this way we correctly simulate the medium behaviour in response to mechanical changes and can possibly evaluate both the effectiveness of the stimulation process and the potential to induce seismicity as a function of time.

Furthermore, stimulated fluid flow in geothermal reservoirs can produce surface Self-Potential (SP) anomalies of several mV. A commonly accepted interpretation involves the activation of electro-kinetic processes. SP anomalies observed above the Soultz-sous-Forets geothermal reservoir while injecting cold fresh water have been modelled from the retrieved fluid fluxes, using the Electric Currents interface in COMSOL Multiphysics®.

Using these procedures we can give insight into the process of reservoir stimulation and its potential to induce seismicity, by comparing theoretical expectations with a well known real case, namely the 2003 Soultz-sous-Forets experiments.