Modeling Self-Potential Effects During Reservoir Stimulation in Enhanced Geothermal System

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Abstract

Geothermal systems represent a large resource that can provide, with a reasonable investment, a very high and cost-effective power generating capacity. Considering also the very low environmental impact, their development represents, in the next decades, an enormous perspective (MIT Report, 2006). Despite its unquestionable potential, geothermal exploitation has long been perceived as limited, mainly because of the dependence from strict site-related conditions, mainly related to the reservoir rock's permeability and to the high thermal gradient, implying the presence of large amounts of hot fluids at reasonable depth. Many of such limitations can be overcome using Enhanced Geothermal Systems technology (EGS, Majer et al., 2007), where massive fluid injection is performed to increase the rock permeability by fracturing. This is a powerful method to exploit hot rocks with low natural permeability, otherwise not exploitable. Numerical procedures have already been presented in literature reproducing thermodynamic evolution and stress changes of systems where fluids are injected (Troiano et al., 2013). However, stimulated fluid flow in geothermal reservoirs can produce also surface Self-Potential (SP) anomalies of several mV. A commonly accepted interpretation involves the activation of electrokinetic processes. Since the induced seismicity risk is generally correlated to fluid circulation stimulated in an area exceeding the well of several hundreds of meters, the wellbore pressure values can be totally uncorrelated to seimic hazard. However, SP anomalies, being generated from pressure gradients in the whole area where fluids flow, has an interesting potential as induced earthquake precursor.

In this work, SP anomalies observed above the Soultz-sous-Forets (Alsace, France) geothermal reservoir while injecting cold water have been modeled, considering a source related to the fluid flow induced by the well stimulation process. In particular, the retrieved changes of pressure due to well stimulation in the EGS system have been used as a source term, to evaluate the electric currents generating the potential anomalies, using COMSOL Multiphysics® simulation. In such a way, SP anomalies generated during the stimulation process at Soultz-sous-Forets have been simulated in order to evaluate the effectiveness of SP monitoring to mitigate the induced seismicity risk.