Geophysical Research Abstracts
Vol. 18, EGU2016-15108-2, 2016
EGU General Assembly 2016

Modeling stress/strain-dependent permeability changes for deep geoenergy applications

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Rock permeability is a key parameter in deep geoenergy systems. Stress and strain changes induced at depth by fluid injection or extraction may substantially alter the rock permeability in an irreversible way. With regard to the geoenergies, some applications require the permeability to be enhanced to improve productivity. The rock permeability is generally enhanced by shearing process of faults and fractures (e.g. hydroshearing for Enhanced and Deep Geothermal Systems), or the creation of new fractures (e.g. hydrofracturing for shale gas). However, such processes may, at the same time, produce seismicity that can be felt by the local population. Moreover, the increased permeability due to fault reactivation may pose at risk the sealing capacity of a storage site (e.g. carbon sequestration or nuclear waste disposal), providing then a preferential pathway for the stored fluids to escape at shallow depth.

In this work we present a review of some recent applications aimed at understanding the coupling between stress (or strain) and permeability. Examples of geoenergy applications include both EGS and CO_2 sequestration. To investigate both "wanted" and "unwanted" effects, THM simulations have been carried out with the TOUGH-FLAC simulator. Our studies include constitutive equations relating the permeability to mean effective stress, effective normal stress, volumetric strain, as well as accounting for permeability variation as related to fault/fracture reactivation. Results show that the geomechanical effects have a large role in changing the permeability, hence affecting fluids leakage, reservoir enhancement, as well as the induced seismicity.