Geophysical Research Abstracts
Vol. 21, EGU2019-9209, 2019
EGU General Assembly 2019

Modelling thermo-hydro-mechanical processes in faulted geological systems - A benchmarking study

Dejian Zhou, Alexandru Tatomir, and Martin Sauter
University of Goettingen, Geoscience Center, Applied Geology, Germany (dejian.zhou@stud.uni-goettingen.de)

Modelling of non-isothermal multiphase flow in porous media has been widely employed in engineering applications such as geological disposal of nuclear waste, geological storage of carbon dioxide, high-temperature geothermal systems, or hydraulic fracturing for shale gas exploitation. Here, coupled thermo-hydro-mechanical (THM) processes play a key role, e.g. injection of cold CO_2 into hot saline aquifers initiating hydromechanical deformation as a result of the temperature effects on the mechanical properties of the rock and / or high-pressure injection into the aquifer with poro-elastic effects as well as fault reactivation. Therefore, there is a need to expand and test the existing models. In this sense, a linear elastic non-isothermal two-phase flow in porous media model had been built. The main objective of this study is to compare the results of the THM model with several literatures reported studies. Flow in porous media constituting the "hydraulic" part of the THM model is based on Darcy's law, "thermal" effect is based on the heat transport equation, while the "mechanics" follows Biot's concept of poroelasticity.

The first comparison example is the "Horstberg" benchmark model proposed in Holzbecher et al., (2014). The geological environment consists of two aquifers connected through a permeable fault as the main application concerns deep geothermal production in a fault zone. The non-isothermal single-phase flow geomechanical model is applied to the three-dimensional domain with the dimensions 5x5x5km^3. The temperature gradient is 0.03K/m with 298.15K at the top of domain along the vertical direction. Cold water (293.15K) is pumped with an injection rate of 40 m^3/h while the same amount is abstracted at the other well both hydraulically connected to the fault. The results are compared with respect to state variables deformation, pore pressure, and temperature at different locations of the domain. The second comparison example was proposed by Rutqvist et al., (2013) and comprises an isothermal multi-phase flow problem with a fault reactivation feature. The parameters and boundary conditions resemble those encountered in the Marcellus shale play at approximate 1500 m depth. The two-dimensional model domain size is 2km x 2km having a 1 km long fault dipping at angle of 80° and located vertically in the centre of the model domain. The material properties (hydraulic and geomechanic) are assumed as homogeneously distributed. Furthermore, we use the Mohr-Coulomb criterion to evaluate the potential for shear failure on the fault. The results are compared in terms of the state variables pore pressure, slip, and shear stress.

Holzbecher E, Oberdorfer, P. (2014) Rock Deformation due to Geothermal Heat Production - a Modelling Study. Oil Gas European Magazine 40(1): 25-26

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