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Thermo-Hydro-Mechanical Evolution of Transport Properties in Porous Media: From Laboratory to the Groß-Schönebeck Geothermal Reservoir.

Antoine Jacquey (1), Mauro Cacace (1), Guido Blöcher (1), Norihiro Watanabe (2), and Magadalena Scheck-Wenderoth (1)

(1) German Research Center for Geosciences GFZ, Potsdam, Germany (ajacquey@gfz-potsdam.de), (2) Center for Environmental Research UFZ, Leipzig, Germany (norihiro.watanabe@ufz.de)

Quantifying variations of transport properties of porous material, which are porosity and permeability is of special interest for geothermal applications. Variations of these properties result from the coupling between rock deformation and thermal processes. Significant pore pressure and temperature changes can occur during injection and production of fluid. Such changes have a direct impact on the stress-field affecting the geothermal reservoir performance. Understanding the coupling between deformation of the porous material and variation of its properties for mass and energy transfer is therefore a major focus for any geothermal operations. Deformation of a porous material filled with fluid is based on variations of bulk and pore volumes and affects therefore the basic transport properties of the rock. Variations of the transport properties can be expressed by theoretical formulations based on experimental observations and then integrated into numerical models which can be used to predict reservoir performance at the field scale. The aim of this study is to develop a complete poro- and thermoelastic formulation capable of explaining and quantifying fluid-rock interactions in a context of geothermal applications.

In a first step, formulations to quantify porosity variations are tested with the open-source finite element method based software OpenGeoSys (Kolditz et al. 2012) and compared to laboratory experiments to constrain the parameters involved. Numerical description of the physical phenomena involved for such behavior requires to account for the coupling between deformation, thermal and hydraulic processes and the relations between different scales.

Three different formulations with H-M coupling are studied which are based on the theories of poroelasticity and crack closure (Zimmerman 1991, Blöcher et al. 2013 and Chin et al. 2000). These three formulations are tested on two different kinds of sandstones (Flechtinger and Bentheimer sandstones) by comparing simulations to experimental results. It is then possible to constrain some parameters involved in these porosity formulations.

One formulation with T-M coupling is also investigated (Ghabezloo et al. 2008) which is based on thermoelasticity and a fluid volume balance.

Then, this theoretical background has been applied to the field scale to study the performance of the Groß-Schönebeck geothermal reservoir situated in the North-East German Basin. Current results on numerical simulations of Thermo-Hydro-Mechanical coupled processes involving transport properties evolution will be presented.