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A simplified fracture network model for studying the efficiency of a single well semi open loop heat exchanger in fractured crystalline rock

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Geothermal energy is a renewable energy source particularly attractive due to associated low greenhouse gas emission rates. Crystalline rocks are in general considered of poor interest for geothermal applications at shallow depths (< 100m), because of the low permeability of the medium. In some cases, fractures may enhance permeability, but thermal energy storage at these shallow depths is still remaining very challenging because of the complexity of fractured media. The purpose of this study is to test the possibility of efficient thermal energy storage in shallow fractured rocks with a single well semi open loop heat exchanger (standing column well). For doing so, a simplified numerical model of fractured media is considered with few fractures.

Here we present the different steps for building the model and for achieving the sensitivity analysis. First, an analytical and dimensional study on the equations has been achieved to highlight the main parameters that control the optimization of the system. In a second step, multiphysics software COMSOL was used to achieve numerical simulations in a very simplified model of fractured media. The objective was to test the efficiency of such a system to store and recover thermal energy depending on i) the few parameters controlling fracture network geometry (size and number of fractures) and ii) the frequency of cycles used to store and recover thermal energy. The results have then been compared to reference shallow geothermal systems already set up for porous media. Through this study, relationships between structure, heat exchanges and storage may be highlighted.