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Solar energy storage in saline aquifers: Insights from coupled hydro-thermo-mechanical modeling

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The utilization of saline aquifer for solar energy storage is recognized as a promising solution to address the spatial and temporal mismatch between energy demand and supply. This approach holds significant potential for future renewable energy storage and conversion. Thermal energy storage in saline aquifer can effectively transform intermittent solar energy into stable geothermal energy at high temperatures. In this study, we examine a previously proposed solar energy storage and conversion system. This system entails the initial conversion of solar energy into heat through parabolic troughs, followed by the storage of thermal energy in a saline aquifer facilitated by high-temperature hot water circulation. Currently, the impact of poroelasticity and thermal stress induced by high-temperature hot water injection on injectivity and heat storage efficiency remains unclear. In this study, three-dimensional porosity and permeability fields for typical saline aquifers are generated by geostatistical modelling. The circulation of high-temperature hot water in the aquifer by doublet vertical well system is explored through coupled hydro-thermo-mechanical modeling. We analyze the effects of poroelasticity and thermal stress on the injectivity of hot water. The influences of in-situ stress and permeability heterogeneity on spatial and temporal evolution of hot water zone are then explored. In addition, the efficiency of solar energy storage in various heterogeneous saline aquifer is evaluated and compared. Considering the hydro-thermo-mechanical coupling effects, saline aquifers conducive to solar energy storage are identified. This study enhances our understanding of the mechanisms involved in solar energy storage in saline aquifers, providing crucial insights for its practical implementation.

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