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A three-dimensional reservoir-scale Thermal-Hydrological-Mechanical model of enhanced geothermal systems

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The heat energy resource in the deep earth (3 ~10 km), which is carried by Hot Dry Rocks (HDR), has a huge capacity for geothermal power generation. As a type of conductive geothermal energy, HDR has low rock permeability, so that Enhanced/Engineered Geothermal System (EGS) is developed to artificially increase the heat exchange area and further extract the deep geothermal energy with the connected natural fractures and hydraulic stimulated fracture network. The coupled Thermal-Hydrological-Mechanical (THM) processes largely control the heat recovery efficiency from HDR, and thus real 3D reservoir scale investigations that account for the multiphysics coupling mechanisms are needed to inform geothermal energy recovery from HDR.

In this work, we built a three-dimensional THM model for the EGS of Qiabuqia HDR (Zhang et al. 2018, Gonghe Basin, China) by taking advantage of the novel simulation framework, GEOSX (Settgast et al. 2022). As a rapidly growing open-source multi-physics simulator, GEOSX has highly scalable algorithms for solving complex fluid flow, thermal, and geomechanical coupled systems. Preliminary geological data of the target area has been acquired by exploratory wells (e.g., GR1, GR2, DR3, DR4). There is also a trial production well GH-01. In our model, we considered a dual-well utilization system. Our 3D model focuses on reservoir-scale THM coupling, and takes into consideration the geostress directions in configuring the faults and (hydraulic)fractures, which are explicitly handled with EDFM (Embedded Discrete Fracture Model) method. The simulated results of heat recovery efficiency under different production scenarios provide guidance information for engineering practices.

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