Numerical simulation of mechanical and chemical permeability evolution near a cooling pluton and its impacts on the formation of natural supercritical geothermal resources

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We present numerical simulations of mechanical and chemical permeability evolutions near a cooling pluton and its impacts on the formation of natural supercritical geothermal resources. Permeability behavior at the supercritical state and/or the brittle-ductile-transition (BDT) zone is of great interest for understanding and exploiting supercritical geothermal systems. Recent experimental studies suggest mechanical and chemical processes could have significant impacts on the permeability changes under the conditions. Watanabe et al. (2017) reported the effective stress primarily controls the permeability of fractured granitic rocks even at a temperature above the critical temperature of water. Furthermore, Saishu et al. (2014) showed that nucleation-driven silica precipitation could take place near the critical point and its instantaneous reaction may play an important role in the formation of a low permeable zone at depth and subsequent developments of shallower natural convective geothermal systems as well as deeper supercritical geothermal systems. This study is aimed at understanding permeability changes driven by the mechanical and chemical processes near a cooling pluton and investigate their impacts on the temporal and spatial development of potentially exploitable supercritical resources in granitic environments. For this purpose, we extended the multiphase flow simulator HYDROTHERM (Kipp et al., 2008; Weis et al., 2014) to include the new stress-dependent and silica dissolution/precipitation effects on its permeability model and modeled the system evolution in a 2D axisymmetric domain. Current results show that the extent and lifetime of the supercritical resources are largely affected by the permeability model as well as the host rock permeability, the intrusion depth, and its radius.

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