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Dynamic permeability evolution during fluid injection and production in ultra-deep geothermal reservoirs

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A geothermal well drilled into a reservoir at temperatures exceeding the critical point of pure water (>374 °C) could generate substantially greater quantities of energy than conventional geothermal wells. Although these temperatures can be found at shallow depths (<2-3 km) in high-grade geothermal resources located in volcanically active areas, similar temperatures are only found at depths >10 km beneath vast areas of continental crust with lower heat fluxes. Permeability decreases markedly with increasing depth below 2-3 km, so exploiting the tremendous heat resources of high temperature rock at such great depths will require permeability stimulation by the injection of high-pressure fluids. In this study, we use the CSMP++ platform to perform 3D simulations of transient permeability evolution around a geothermal doublet drilled to depths between 10-16 km. The simulations incorporate a well model initially devised by Peaceman (1978) to calculate well pressures and rates of fluid production/injection. The dynamic permeability model is based on Weis et al. (2012), initially developed to simulate the evolution of ore-forming magmatic-hydrothermal systems, and links a failure criterion for critically-stressed crust with depth-dependent permeability profiles characteristic for tectonically active crust as well as pressure- and temperature-dependent relationships describing hydraulic fracturing and the transition from brittle to ductile rock behavior. We investigate the permeability changes in response to high-pressure fluid injection in brittle and ductile rock, the timescales over which the zone of permeability stimulation migrates towards production wells, and dynamic permeability evolution in response to changes in injection and production parameters. These simulations aim to mitigate resource risks that could limit the ability to extract heat from geothermal resources in ductile upper crust and to help anticipate the conditions that would be required to make the exploitation of ultra-deep supercritical geothermal resources a reality.

References

Peaceman, D. W. (1978) Interpretation of Well-Block Pressures in Numerical Reservoir Simulation. SPE 6893, 183–194.

Weis, P., Driesner, T., & Heinrich, C. A. (2012). Porphyry-copper ore shells form at stable pressure-temperature fronts within dynamic fluid plumes. Science, 338(6114), 1613–1616.