

Reactive-Transport Modelling Of the Native-State and Enhanced Geothermal Systems At Newberry Volcano, Oregon

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Enhanced Geothermal Systems (EGS) in high-temperature rock near magma bodies are under development or planned at several sites worldwide. Although there are many scientific reasons to explore this technically-challenging regime, the potential economic benefits of high enthalpy systems are an important driver. Permeability stimulation and assessment of long-term sustainability has typically been guided by reservoir (thermal-hydrological-TH) and rock mechanical modeling. However, at higher temperatures the effects of water-rock-gas-(supercritical fluid) interaction and inelastic mechanical deformation control many aspects of permeability creation and its temporal/spatial evolution. Successful prediction of TH processes in EGS benefits from a well-constrained “native-state” model that can capture the fluid geochemistry/isotopic characteristics, alteration mineralogy, and pressure-temperature-stress conditions. At Newberry Volcano (Oregon, USA), a borehole was drilled into volcanic and intrusive rock to a depth of ~3000m with a bottom-hole temperature of 330°C. The planned stimulation volume overlaps with a supercritical region adjacent to a magma body at 4-5 km depth. Thermal conductivities and permeabilities were first calibrated in a native-state 3-D model of Newberry Volcano using measured borehole temperature and pressures. These P-T conditions were then used to simulate the hydrothermal mineral distributions and fluid compositions over ~100ky. To capture the deep calcite and sulfide mineralization, high Cl fluid inclusions, and elevated ³He/⁴He, along with quartz-chlorite-epidote alteration required slow convection of groundwater through low permeability altered subvolcanic tuffs and silicic intrusives mixing with magmatic fluids high in CO₂, HCl, H₂S, and He. Thermal-hydrological-mechanical-chemical (THMC) models provided the initial stress distribution for the reservoir stimulation model that was then used to simulate injectivity increases owing to shear failure, and geochemical/isotopic compositions in flowback water/gas. These studies proved the value of combining advanced approaches in reactive transport and reservoir modeling for planning EGS development as well as probing the TH and geochemical evolution of magmatic-hydrothermal systems.