Supercritical fluids in geothermal systems: An experimental study

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Fluids with supercritical temperatures (>400°C) and enthalpies (>3 MJ/kg) have been encountered in active geothermal systems at depth [1]. The fluids may originate from magma degassing or form upon conductive heat exchange between magmatic intrusion and the reservoir geothermal fluids (<300°C). Magmatic fluids are characterized by elevated concentrations of volatile elements (H_2O, C, S, Cl) whereas the chemical composition of the latter type is poorly constrained.

This study focuses on supercritical fluid formation heat exchange between an emplaced intrusion and the surrounding groundwater system. Fluid-rock experiments were conducted at 250-420°C and 70 bar to assess the chemical composition of geothermal fluids of meteoric water origin and the processes controlling their composition over vide range of temperature. Based on the experimental results, the fluid composition is controlled by equilibrium with secondary minerals at sub-critical temperature and enthalpy, with dominant constituents being Si, Na, K, Ca, CO_2 and H_2S. Upon conductive heating of such fluids to form single phase fluids at 420°C, (Na, K, Ca)-Al-silicates and halite mineralization occurs, resulting in fluids with concentrations of Cl, B, F, CO_2 and H_2S comparable with the fluids at sub-critical temperature and enthalpy but depleted in other elements like Na, K, Ca and Si.

The experimentally observed fluid composition was similar to the measured composition of fluids from the IDDP-1 well at Krafla (NE, Iceland) that discharged fluids of ~440°C, 140 bar and 3.2 MJ/kg. This supports the hypothesis that fluids with supercritical temperature and enthalpy may form via conductive heating of reservoir geothermal fluids by magmatic intrusions. Our study suggests that this process has an important impact on permeability and mass transfer along the boundary between conventional geothermal systems and magmatic intrusion and contributes to the utilization potential of high enthalpy supercritical geothermal resources.

[1] Reinsch *et al.* (2017) Geotherm. Energy 5, 1-25