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The role of fluid-mineral interactions in stimulated geothermal systems: Insights from two case studies in the Basin and Range, Nevada

SABINE MEHAY[1], LOGAN HACKETT[2] AND JOHN AKERLEY[3]

[1]SLB
[2]GeothermEx/SLB
[3]Ormat

Understanding and predicting geochemical processes in stimulated geothermal reservoirs are critical for optimizing reservoir performance and minimizing operational risks. Mineral deposition within the reservoir, even in small amounts, can reduce the conductivity of the fracture network, while dissolution may increase it. These processes may alter the mechanical properties of the fractures and proppant. This study investigates fluid-mineral interactions during circulation before and after stimulation of a well at the Don A. Campbell (DAC) and the Jersey Valley (JV) geothermal projects, Basin and Range, Nevada.

Batch reaction modeling with PHREEQC was used to reconstruct injection and original reservoir fluids and to predict the evolution of fluid and rock composition and properties, post-stimulation.

Two thermodynamic databases (Thermoddem and SUPCRTBL) were compared to evaluate the impact of thermodynamic properties on modeling results. Negligeable effects were found in fluid mixing scenarios, but large differences were observed in models involving a mineral phase, highlighting the importance of constraining key input parameters (redox state, mineral assemblage variability, non-condensable gas content) and the need for calibration with field data.

At both sites, mixing of injection and reservoir fluid yields fluids at equilibrium with quartz, while other primary minerals (plagioclase, K-feldspar) show decreasing saturation levels with increasing % of injection. Chlorite remains stable, whereas other clay minerals become undersaturated at high % of injection. Oxides are moderately oversaturated. Sulfides oversaturation is relatively prevalent, especially at JV where the risk of iron sulfide precipitation could be further assessed. At DAC, carbonates are slightly oversaturated at all mixing ratios, indicating precipitation may occur. At JV, the fluid shows an increasing degree of undersaturation with respect to calcite with increasing % of injection. Although calcite is present in low abundance in the reservoir (3 wt%), its dissolution would increase fracture conductivity that may support flow distribution in the geothermal system.

Ongoing work using 1D reactive transport models is investigating the evolution of water composition and mineral saturation from injection to the production well for specified flow and temperature conditions, with and without proppant. Fluid composition evolution and risk of scaling under decreasing temperature and pressure (production well) are further assessed.

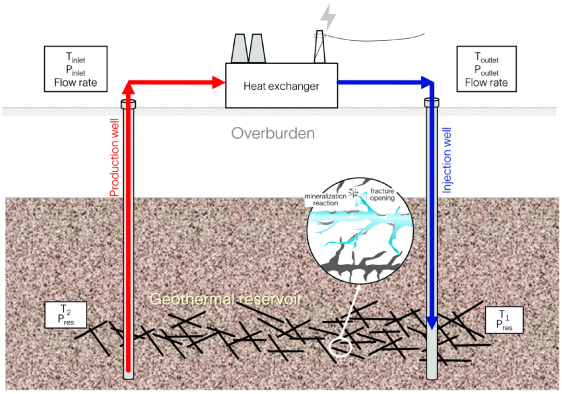

Figure 1. Conceptual model of the production of an enhanced geothermal system illustrating flow paths, P-T constraints and fractures. Chemical reaction impact on fractures modified from Nisbet et al. (Carbon mineralization in fractured mafic and ultramafic rocks: A review. Reviews of Geophysics 62, e2023RG000815. 2024).