



## Modelling Mineral-Scaling in Geothermal Reservoirs Using Both a Local Equilibrium and a Kinetics Approach

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When producing heat from a geothermal well, the produced water cools down in the heat exchanger, and experiencing a lower pressure in the surface processing-facility (1 – 10 bar) than in the reservoir (100 – 300 bar). The decrease in pressure may cause gas to come out of solution. This decrease in temperature and degassing of the produced water may cause precipitation and dissolution (mineralization) to occur. After the produced water is cooled down, it is reinjected into the reservoir through an injection well. Mineralization in the reservoir restricts the flow path of the injected water, resulting in reduced injectivity. Consequently, more energy is required by the injection pump, which results in additional costs, and thereby reduces the project's economic return.

When numerically modeling mineralization in a geothermal reservoir, accounting for the reaction kinetics can be computationally expensive. The simulations can be made less expensive by assuming local equilibrium between the reactants and reaction-products; but using this approach might give results that are not in agreement with experimental findings.

Here we present an analytical model for mineral precipitation in a low-enthalpy geothermal reservoir. We compare the kinetics of the relevant reaction terms with respect to the transport terms (heat and flow) to determine whether the local equilibrium approach (LEA) or kinetics approach (KA) is appropriate for modeling a specific reaction. We focus on the near-wellbore region in the reservoir, where precipitation can behave as a 'skin'; when assuming radial-flow, precipitation in the near-wellbore region has a more dramatic impact on the injectivity than precipitation further downstream in the reservoir.

Using numerical simulations we validate the approach to use different methods of geochemical modelling based on the reaction speed and its potential impact on computation time.

Based on our analysis on mineralization in the near-wellbore-region, the three different reaction regimes can be distinguished when comparing the time-scale of reaction to the time-scale of transport, viz.: (1) **fast reactions** (mineralization can be considered instantaneous and modelling these reactions using LEA or KA does not lead to significantly different simulation results); (2) **very slow reactions** (no significant change in ion concentrations in the region of

interest, whether these reactions are modelled using LEA or KA); (3) **reaction/transport intermediate zone** (using LEA leads to significantly different simulation results compared to KA).

Accounting for these classifications allows simplification of the current numerical geochemical-models, while still accounting for relevant kinetics of mineralization. This approach was tested using a numerical model of precipitation in a geothermal reservoir.