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Gas phase induced carbonate precipitation - experimental proof and model verification

Lilly Zacherl and Thomas Baumann
Technical University of Munich, Chair of Hydrogeology, Germany (lilly.zacherl@tum.de)

Successful development of the geothermal energy sector requires an understanding of the geological systems and processes that occur within. In the North Alpine Foreland Basin, a hydrogeothermal play type, most sites are affected by inorganic precipitates which reduce the efficiency and safety of plants. Although the gas concentrations in the geothermal waters are generally low, any formation of an independent gas phase induces carbonate precipitation. A quantitative prediction of the precipitates, however, is not yet possible because kinetic data for gas phase induced precipitates is not available.

To address this issue laboratory experiments were run where a gas (CO_2, air) was induced into a column containing an aqueous solution (tap water, water with high salinity). The scalings produced were analyzed by Raman spectroscopy, a mass balance of the process including the dissolving of scaling by inducing CO_2 into the scaled column was based on ion chromatography data. The experiments show that by injecting air into tap water a full stripping of CO_2 occurs which is the experimental proof of the disruption of the lime carbonic acid equilibrium by gas bubbles. The salinity of the initial solution influences - in agreement to previous investigations - the polymorph: only aragonite crystals were detected in tap water (ionic strength: 8.5e-03 mol/L), whereas only calcite crystals showed up in tap water with additional 0.2 g/L NaCl (ionic strength: 1.2e-02 mol/L). Precipitation was inhibited when 120 g/L NaCl were added to the tap water before stripping (ionic strength: 2.1 mol/L).

The data were evaluated using a combination of hydrogeochemical calculation and precipitation kinetics (PhreeqC) with gas bubble kinetics (Python) and PEST++ for the final parameter adjustment. We successfully modelled the process of stripping, CO_2-injection and the experiments with higher salinity with one model. This experimental proof of the gas phase induced carbonate precipitation and the new adequate description of the scaling process is a further step to predictive maintenance for geothermal sites and a more reliable holistic site assessment during the planning stage. Together, this improves the sustainability and the attractiveness of the geothermal energy sector to investors.