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Degassing kinetics of high salinity geothermal fluids

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The formation of free gas bubbles (degassing) is a major issue during production of geothermal fluids. These often contain substantial amounts of dissolved gasses, such as CO_2, CH_4 and N_2. Lower pressures in the region surrounding the production well can cause dissolved gas to come out of the solution. This can have detrimental effects on the production and generally on the operation, such as corrosion of the facilities or reduced water production as the gas limits the space where the water can flow. This study aims to improve the understanding of the conditions under which free gas nucleates, including determination of the bubble point pressure and temperature and the rate at which bubbles form during depressurization.

The focus of this study is on CO_2 degassing from high salinity brines. We report a series of well-controlled depressurization experiments in a pressure cell that allows for visual monitoring of the degassing process. The cell is filled with brine saturated with dissolved CO_2 at high pressure and temperature. The pressure within the cell can be reduced in a reproducible manner thus allowing for repeatable experiments. A high-speed camera paired with a uniform LED light source is used to record the degassing process. The pressure in the cell is monitored using a transducer synchronized with the camera. The resulting images were analysed using an in-house MATLAB code, which allows for determination of the bubble point pressure and rate of bubble formation. Experiments were performed at high pressure (up to 200 bar) and temperature (up to 200 °C) using a fixed CO_2 concentration of 200 mmol/L (i.e. 8.8 g/L). Two saline brine solutions are used to assess the influence of the salt concentration on the bubble nucleation process: a low salinity (1 M NaCl) and a high salinity (1.5 M $CaCl_2$ + 2 M NaCl) solution.

A model based on the geochemical software PHREEQC was also developed to predict the solubility of CO_2 in high salinity geothermal brines. This model allows for simulating the degassing behaviour at the same conditions as those used in the experiments. From these simulations, the theoretical bubble point pressure and temperature can be estimated along with the rate of gas exsolution during a depressurization process. As there are several alternative equation-of-states for CO_2 in solution with brines, a comparative matching of the depressurization experiments with individual formulations is presented.