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The geochemistry of CO_2 reinjection into geothermal reservoirs: combining experimental and modelling approaches

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Geothermal brines produced for energy generation contain small but significant amounts of dissolved non-condensable gases (NCG), primarily CO_2. This CO_2 is typically released to the atmosphere, but the drive to reduce greenhouse gas emissions through both societal and policy-driven pressures has led geothermal operators to explore the potential for NCG reinjection into geothermal reservoirs. However, the effect of this reinjected CO_2 on the long-term geochemical behaviour of the reservoir is poorly understood, and remains a key barrier to the widespread deployment of reinjection technologies. Previous experimental work at GNS has shown that under reservoir pressure-temperature conditions, the addition of CO_2 during reinjection can significantly slow silica polymerisation, and may have a beneficial effect on the extent of silica scaling [1], which is a key operational challenge in geothermal energy production.

In this study, we build upon this previous and ongoing experimental work by developing a reactive transport model framework in PFLOTRAN to enable a more detailed investigation of these geochemical processes. Using an inverse approach, we calibrate mineral precipitation and dissolution kinetics by fitting model parameters to experimental data. Our results show that for a reservoir comprised of a typical New Zealand brine interacting with a greywacke substrate, increasing levels of CO_2 consistently slow the expected rate of silica scaling, although the majority of this effect is achieved by around 100 ppm CO_2. Reservoir-scale simulations further reveal that the slowed silica precipitation rate allows porosity around the injection well to be maintained for significantly longer when the reinjection brine contains added CO_2. By making quantitative predictions regarding the long-term effects of CO_2 reinjection into geothermal reservoirs, we aim to de-risk and accelerate the adoption of NCG reinjection strategies in New Zealand and worldwide.

[1] Mountain et al. (2022), CO_2 as an effective silica scaling inhibitor during reinjection of acid-dosed geothermal brines: An experimental study, Goldschmidt Abstracts