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CO_2 as an effective silica scaling inhibitor during reinjection of acid-dosed geothermal brines: An experimental study

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At GNS, we have been simulating brine re-injection in a number of geothermal scenarios. We conclude that the important controls on the rate of amorphous silica (AmSi) scaling are temperature, SiO_2 concentration, and the calcite content of the formation. Calcite neutralises acidity, causes pH increase, and induces AmSi precipitation. We proposed that re-injection of CO_2 with the brine will suppress pH shift, deter SiO_2 polymerisation, and AmSi precipitation.

Four experiments were conducted using NZ greywacke and acid-dosed brine (pH 4.2, 840 ppm SiO_2). A continuous-flow apparatus with two autoclaves was used. The first autoclave (250°C/70 bar) was empty and depolymerised silica in the brine. The second held the rock at 150°C/70 bar.

The initial experiment used greywacke and brine only. The effluent pH shifted to 7 and then declined to 5 over 28 days. SiO_2 loss was initially ~140 ppm and then decreased to zero indicating minimal scaling.

In the second experiment, 0.5 g of calcite was added to the rock. The effluent pH increased to 7.8 and decreased to 7.1 after 28 days. SiO_2 loss was consistently ~140 ppm over the experiment indicating significant scaling.

In the third experiment, calcite was added to the rock and ~2000 ppm of CO_2 to the brine. The initial effluent pH was 5.9 and decreased to 4.2 after 28 days. Silica loss in this case was consistently ~40 ppm, hence the added CO_2 kept pH lower and slowed AmSi precipitation.

In the final experiment, calcite was added to the rock and ~600 ppm of CO_2 to the brine. This was to test the sensitivity of AmSi scaling rate to CO_2 concentration. The initial effluent pH was 6.2 which decreased to 5.2 by the end of the experiment. SiO_2 loss was initially ~70 ppm but this decreased to 40 ppm after 28 days. These results show that with only 600 ppm of CO_2 in the brine, AmSi precipitation was also inhibited.

The results indicate that re-injection of CO_2 may not solely be a cost but could have positive economic benefits for the maintenance of formation injectability, particularly when the formation contains significant calcite.