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Horizontal wells placement optimization for CO2 geological storage in confined aquifers subjected to brine recycling

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Geological storage of CO_2 has potential of mitigating CO_2 emissions into the atmosphere. CO_2 in geological formations can be trapped through solubility, residual, mineral, and structural trapping mechanisms. Of these trapping mechanisms structural trapping is likely to be the least secure because CO_2 accumulated at the cap-rock can potentially leak through pressure-induced fractures in the cap-rock.

In order to maximize the trapping of CO_2 and at the same time prevent the leakage of CO_2, placement of injection and production wells were optimized in a saline aquifer subjected to brine recycling under the constraint of a fixed maximum bottomhole pressure which corresponds to the breakthrough pressure of the cap-rock. Contrary to previous well placement optimization studies, in this study the target geological formation is a confined saline aquifer, permeability is heterogonous (10 - 100 md), and wells for CO_2 and brine injection are horizontal. TOUGH2-ECO2N and an iterative Latin hypercube sampling optimization method were employed for the multiphase flow and optimization calculations, respectively. Optimization variables included the locations of two CO_2 injection wells and one brine production well, as well as the injection rate of CO_2. The total volume of the geological model is 20 km × 20 km × 0.1 km which has 4 layers initially containing only brine at a temperature of 40 ℃ and pressure of 10 MPa at the top layer. Simulations were performed for 30 years of CO_2 injection at rates of 5 - 20 kg/s, and 10 years of brine production and/or recycling. The two injection wells for brine recycling were located above the two CO_2 injection wells.

Optimizations of wells placement were performed for two scenarios: 1) injection of CO_2 without brine recycling, and 2) injection of CO_2 with brine recycling. Our optimization results indicate that placing brine injection wells above CO_2 injection wells in conjunction with equal fractions of brine recycling and CO_2 injection to each well leads to highest amounts of dissolution and residual trapping of CO_2. The trapping of CO_2 was improved by 5.4% with brine recycling in comparison to the trapping of CO_2 obtained without recycling (13.26 Mt). Although CO_2 was confirmed to be produced along with brine from production wells located near the injection wells, placement of the production well has shown to have little to no affect on the trapping of CO_2 under the given conditions. With regard to the optimal placement of injection wells, 3 and 6 potential areas were clearly identified for scenario 1 and 2, respectively. It is theorized that heterogeneous permeability formations may have multiple local optima; however this is yet to be confirmed.

Keywords: CO2 geological storage, Well placement, Brine recycling, Optimization