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Reactive transport modeling of the long-term effects of CO_2 storage in the P18 depleted gas field

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Depleted gas fields are an import CO_2 storage sink for The Netherlands, with a total storage capacity of more than 3 Gtonne. The CO_2 sources are located at relatively short distances from potential storage reservoirs and an infrastructure for (cross-border) gas transport over large distances already exists. Several depleted gas fields in the subsurface of the Netherlands have yet been evaluated as potential locations for CO_2 storage (for example the K12-B field). The P18 gas field is located in the offshore of The Netherlands and is currently evaluated as potential CO_2 storage reservoir. The aim of this study is to predict the long-term effects of CO_2 injection into the P18 field using reactive transport modeling (TOUGHREACT).

The storage reservoir is described using the mineralogy and petrophysical characteristics of three geological layers in a radial (R,Z) reservoir model with top depth of 3456 m, a thickness of 98 m, and 3300 grid cells. The initial reservoir temperature was defined as 90 degrees C with an initial (depletion) pressure of 20.0 bars. Capillary pressure curves are based on empirical relations. The CO_2 is injected uniformly distributed over the model height, at a constant rate of 35 kg/s (1.1 Mton/year), and a temperature of 40 degrees C for 30 years. The well is then shut-in with a reservoir pressure of approximately 375 bar. The simulations are continued up to 10,000 years for computing the long-term effects in the reservoir.

The results show that the near-well area is dried out during injection, leading to salt precipitation and reduced permeability during injection. Condensation of the evaporated water occurs outside the near-well area. Water imbibition is modelled after shut in of the well, leading to rewetting of the near-well area and redissolution of the salt. Most geochemical reactions need water to occur, including well-cement minerals, and therefore predictions of water flow after well shut-ins are important to take into account. Experimentally determined porosity-permeability and capillary pressure relationships on core plugs from the reservoir are needed to draw more quantitative conclusions on water flow and salt precipitation in the reservoir. Dissolution of CO_2 in the formation water leads to a pH decrease, which is then slowly buffered by mineral dissolution and precipitation reactions. This leads to porosity changes and CO_2 trapping in several carbonate minerals (e.g. calcite, dolomite, dawsonite, and magnesite). Geochemical reactions were still ongoing after 10,000 years, indicating that the reservoir was not yet in equilibrium after this period.