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Short and long-term multiphase reactive transport processes during a pilot test of air injection into a sandstone gas storage facility

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This study is based on unique field data on a 3-year pilot test during which air containing 8 mol% O_2(g) was injected as a cushion gas into a natural gas reservoir, a carbonate-cemented sandstone aquifer located in the Paris Basin (France) [1]. The oxygen was fully depleted several months after injection completion, meanwhile CO_2(g) was detected around 2–6 mol%; the pH decreased from 8 to 6, while reducing conditions shifted to mildly oxidizing ones with increasing concentration of sulfates in equilibrium with gypsum. After the test completion, the long-term evolution of the aquifer was assessed by a 15-year survey. The pH gradually returned to its near initial state and sulfates were reduced by 2 to 3 times. Data on the release of trace metals (Ba, Cu, Pb, Zn) during and after the test were also available.

Multiphase reactive transport models were developed on these field data using the HYTEC reactive transport code in 2D-reservoir configurations [1]. At the short-term scale, modeling focused on the gas-water-rock reactive sequence during the air injection: 1/ depletion of the injected O_2(g) due to pyrite oxidation, 2/ leading to acidity production and dissolved sulfates, 3/ acidity buffering by calcite dissolution, 4/ followed by gypsum precipitation and CO_2(g) exsolution. At the long-term scale, the modeling tackled with the progressive return to the baseline chemistry of the deep aquifer that was 1/ mostly driven by transport processes and 2/ to a lesser extent, slow water/rock chemical interactions.

These field-based models developed at short and long-term could be used as a workflow for other gas storage facilities, e.g. biomethane, compressed air, and CO_2.

[1] Sin, I., De Windt, L., Banc, C., Goblet, P., Dequidt, D. (2023). Assessment of the oxygen reactivity in a gas storage facility by multiphase reactive transport modeling of field data for air injection into a sandstone reservoir in the Paris Basin, France. *Science of The Total Environment* 869, 161657.