

Multiphase reactive transport modeling of oxygen effect on deep gas storage aquifers

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The on-going development of biomethane production, as an alternative to fossil fuels, will increase its proportion in natural gas infrastructures. In underground gas storage facilities, oxygen in biomethane may react with and disturb the groundwater chemistry, reservoir rock and modify the stored gas proportions. This study aimed to understand the different phenomena occurring in the underground due to the presence of $O_2(g)$ and to assess its possible detrimental effects for two different sites of natural gas storage in deep aquifers in France with the multiphase reactive transport code HYTEC [1]. *In situ* petrological and geochemical characteristics were carefully modelled using equations of state for phase equilibria and relevant kinetics for mineral dissolution and precipitation. Reservoir 1 was a sandstone cemented with calcite-clay at a mean temperature of 30°C and pressure of 45 bars. Reservoir 2 was a felspathic sandstone cemented with clay at a mean temperature of 55°C and pressure of 115 bars. The pH was around 7.9 and the ionic strength about 0.5 in both reservoirs. Sensitivity study on the $O_2(g)$ content (10 – 10000 ppm) and kinetics parameters were performed to increase overall confidence in the model.

The modeling showed that groundwater acidification was the main geochemical disturbance. The model indicated that acidity mainly came from pyrite oxidation by $O_2(g)$ and, to a lesser extent, the solubilization of $CO_2(g)$ (1000 ppm) and $H_2S(g)$ (10 ppm) from the natural gas (Fig.1). Complete and partial oxidation of pyrite were considered. The higher pressure of Reservoir 2 promoted gas solubilization. Stronger acidic conditions could be reached in non-favorable scenarios, especially for Reservoir 2, with the highest $O_2(g)$ contents and the complete dissolution/passivation of calcite. Injection of O_2 at 100 ppm has a limited impact on pH in both reservoirs. The pH was efficiently buffered by calcite dissolution and, to a lesser extent, anorthite dissolution. The effect of the primary mineral dissolution on the total porosity was partly balanced by the precipitation of gypsum, goethite, and possibly elemental sulfur at the lowest $O_2(g)$ contents.

[1] Sin, Lagneau et Corvisier (2017), Adv Wat Res 100.

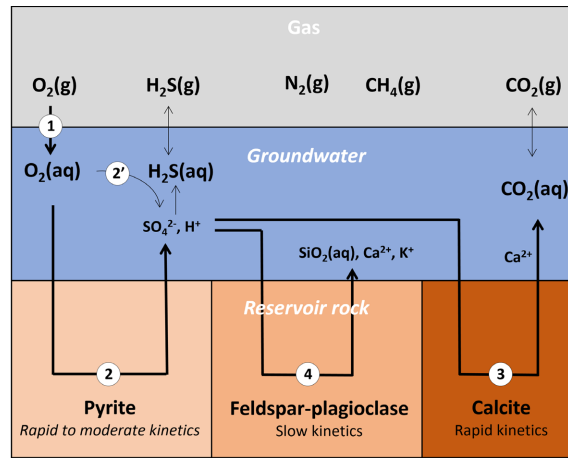


Figure 1. Induced geochemical reactions by oxygen injection.