



## Geochemical effects of impurities in CO<sub>2</sub> on long-term storage integrity

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CO<sub>2</sub> capture and storage (CCS) is considered as a potential means of CO<sub>2</sub> emission reduction. Emitted CO<sub>2</sub> is, however, almost never a pure stream. Depending on its source, a number of impurities can be present in variable amounts. For geological storage, the most important ones are O<sub>2</sub>, H<sub>2</sub>S, SO<sub>2</sub> and NO<sub>x</sub>. These impurities, even if present in low concentrations, are able to influence the pH of the formation water and may subsequently disturb geochemical, and accordingly geomechanical, properties of the reservoir rock, cap rock and well bore material. Purification of the CO<sub>2</sub> stream at the source is very costly and requires a lot of energy. Therefore, it is important to investigate the severity of the effects of these impurities.

Geochemical interactions between different impurities, CO<sub>2</sub> and brine are complex and not yet understood. It is known that the pH of the formation water decreases to values of around 4 after CO<sub>2</sub> dissolution. Previous modeling research using PHREEQC (Koenen et al., 2010) predicts formation of nitric and sulfuric acid due to dissolution of impurities and reaction with other aqueous species in the formation water. The presence or absence of O<sub>2</sub> is of great importance, especially in the oxidation of H<sub>2</sub>S. Accordingly, the pH of the brine may decrease to values lower than 3, depending on the types and concentration of impurities in the stream. This effect could be severe near the injection well due to the high solubility and further dissociation of the impurities. Acidic formation water near the injection well could affect the integrity of well-bore cement, unless drying out of the well-bore area occurred as a result of water evaporation into the CO<sub>2</sub>. In the latter case, transport of impurities into the reservoir may cause brine acidification and geochemical reactions of minerals in the reservoir and cap rock.

According to Ellis et al. (2009) the long-term pH effect of impurities in an aquifer will, even on a time scale of thousands of years, be limited to a narrow zone at the contact of the supercritical CO<sub>2</sub> (scCO<sub>2</sub>) plume and the water saturated area. Diffusion of impurities within the CO<sub>2</sub> and within the brine is assumed to be slow. However, dissolution of impurities will also occur in residual (capillary) brine in the unsaturated zone (or in a depleted gas reservoir), with pH lowering and alteration of the geochemical balance as a consequence. For the cap rock such effects will be diffusion limited, but a narrow and upward progressing acid front seems likely.

In this work several PHREEQC geochemical modeling approaches are applied to study the effects of impurities at the interfaces of the reservoir, cap rock, and well-bore area in more detail. The first results show that progress of the acidification front in the cap rock is predicted to be highly dependent on the diffusion coefficients assumed. Sensitivity of several other parameters is investigated. The results will show in more detail the rate and severity of the potential geochemical degradation of the materials as a consequence of the presence of impurities.

### References

Ellis B.R., Crandell L.E. and Peters C.A., 2010. Limitations for brine acidification due to SO<sub>2</sub> co-injection in geologic carbon sequestration. *International Journal of Greenhouse Gas Control* 4, 575-582

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