We study the geochemical and hydrodynamic changes induced by massive injection of CO2 into the chloride/zeolite-rich sandstone of the Katnoook reservoir, Pretty Hill formation (Otway Basin Australia). The Katnoook field, where the sample come from, presents Si-rich minerals containing divalent cation such as chamosite and laumontite which can induce carbonate precipitation and thus CO2 mineral storage.

In the following we will report the results based on two CO2-rich brine percolation lab-scale experiments reproducing in situ reservoir conditions at the Katnoook Pretty Hill formation (i.e. T = 95 °C and P = 10 MPA). The fluid injected at constant flow rate is a rock-equilibrated brine subsequently enriched in CO2 up to partial pressure of 6 MPa. We observe feldspars, laumontite and kaolinite dissolution, kaolinite and silica precipitation and a noticeable sink of CO2 in the sample which is attributed to carbon precipitation. The precipitation of amorphous carbon due to the reduction of CO2 is link to the oxidation of the iron and the precipitation of Fe-oxyde. Conversely, permeability decreases of about one order of magnitude due to the localization of the kaolinite precipitation in the main flow paths.

Yet, the high reactivity of this sandstone makes this reservoir a valuable target for CO2 mineralization, but the associated permeability decrease may limit the injection rate and the spreading of the CO2 in the reservoir.

The methodology combines chemical analysis of the fluid, continuous measurements of sample permeability, and pore-scale characterisation of the rock before and after each experiment using ESEM and TEM.

Precipitation reactions

The ratio Fe:Si in the fluid indicate that Fe is retained in the sample. It can be precipitated as Fe-carbonate or carbonate.

The CO2 concentration variation ($\Delta$C) is negative. This shows that CO2 is stored in the sample. The decrease of the value of C CO2 follow the decrease of Fe:Si ratio. This denote the precipitation of Fe-rich carbonate or a couple redox reaction with the formation of Fe-oxyde and amorphous carbon.

Total and organic carbon analyses after experiment indicate that both carbonate minerals and organic carbon have precipitated during the percolation experiment.

The permeability decreases from 1.48 mD to 0.094 mD. The permeability decrease can be due to the precipitation of poorly permeable minerals like nanoporous clay.

Minerals such as feldspar, chamosite and laumontite are dissolved and the precipitation of kaolinite and silica is observed. Precipitation of carbonate minerals is also recorded either as Fe-rich carbonate (ankerite, siderite) and as graphite coupled with Fe-oxyde. These minerals testify of a stable mineral storage of CO2 in such sandstone reservoirs.

Nevertheless, hydrated minerals precipitation such as kaolinite induces permeability decrease and also complicates the reactive surface accessibility. The percolation experiments presented here emphasize the permeability decrease measured during CO2-rich brine percolation into Katnoook sandstone samples. This permeability change might reduce the injection performance and the spreading of CO2 into the reservoir.

Conclusions

These percolation experiments, performed for conditions representative of in situ reservoir conditions, provide new information on reactive mechanisms between CO2-rich brine and chloride/zeolite-rich sandstone. They have showed that the Katnoook sandstone from Otway basin strongly reacts during the CO2-rich brine.

Conversely, quartz grains appear to be unaltered during the CO2-rich brine percolation.