A possible way to remedy leakage from reservoirs of geological CO2 storage

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At depth of 800 - 3000 m, which is considered economically feasible for injecting CO_2, the density of injected CO_2 is still smaller than that of water by several tens of percent. The difference in density of CO_2 and water causes buoyancy force, and it should bring upward migration of CO_2 through pores in rock. Thus CO_2 storage reservoirs should be covered with a sufficiently impermeable seal, i.e. caprock, in order for trapping to inhibit the upward migration of CO_2. Furthermore, the caprock has an area of several kilometers and thickness of several tens of meters, and it should be perfect not to contain permeable faults and fractures. However, it may be not easy to find places with such ideal conditions, especially in regions with relatively active crustal dynamics such as Japan. Considering this situation, we have proposed the in-situ reaction barrier method (Ito et al., GHGT, 2006), which can be applied to reduce the medium permeability along potential leakage paths of a deep CO_2 storage reservoir. In this method, an aqueous solution will be injected into the fractures and rocks through injection wells. The solution will have a low viscosity and will not impact formation permeability as long as the solution is left as it is, but when the solution encounters dissolved CO_2, precipitation will occur due to chemical reaction. As a result, the permeability will be reduced by filling the pores and fractures in the rocks with the precipitates. The solution is referred to the reaction grout. In the present study, we demonstrated this method by laboratory experiment using the reaction grout of Na_2O $nSiO_2$. In this case, siliceous precipitation, $nSiO_2$, will be produced by chemical reaction between the (Na_2O $nSiO_2$) solution and CO_2.

For the experiment, we prepared a cylindrical pressure vessel filled with glass beads and water to represent porous rocks at about 1000 m deep. The outline of the experiment is summarized as follows; (i) Fill up the vessel with water, and raise water pressure and temperature in the vessel to 10 MPa and 40 degrees C. (ii) Inject the reaction grout into the medium. (iii) Inject CO_2 from the lower end of vessel. Then the injected CO_2 meets with the reaction grout injected at the previous step. (iv) Measure the permeability of the simulated rock in the vessel periodically. The results show that the evaluated permeability decreased drastically and it was stabilized afterwards for 5 days until the end of experiment. The viscosity of the reaction grout of Na_2O $nSiO_2$ is just few time larger than water, and the siliceous precipitation of $nSiO_2$ is stable in low pH condition. Thus the Na_2O $nSiO_2$ solution is promising to be the reaction grout used for the in-situ reaction barrier method.