Conducting Batch Reactions at Relevant Geologic Carbon Sequestration Conditions

TELEDYNE ISCO
Everywhereyoulook™

Syringe Pump Application Note
AN42

Overview

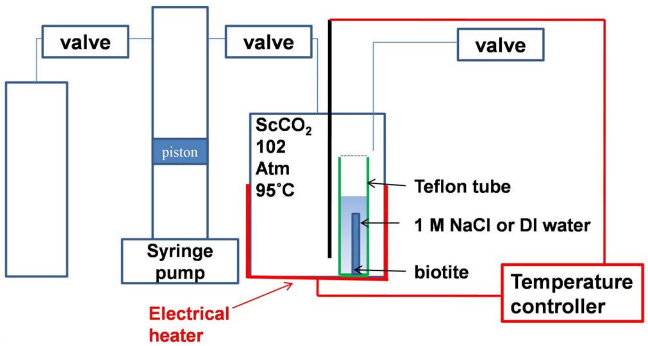
Geologic carbon sequestration (GCS) is needed to mitigate global warming caused by increased atmospheric CO_2 concentrations. For safe and efficient GCS operations the geochemical reactions with CO_2-brine-rock under relevant GCS conditions needs to be studied. For this application CO_2-brine-biotite interactions were studied and fibrous illite formation was observed after reaction for only 3 hours. The fibrous illite detached and released into solution after longer reaction time, indicating potential permeability decrease in the aquifer, as fibrous illite can clog the pore spaces affecting further CO_2 injections.

Experiment

At GCS sites, there is high temperature and high pressure, with high salt concentrations (especially NaCl) in the brine. To mimic the GCS conditions, as shown in the Figure 1, gas (e.g, CO_2) can be injected into the high temperature reactor by the Teledyne ISCO syringe pump. This single pump set-up was used for its ability to maintain a constant pressure. During reaction, CO_2 may dissolve into the solution. However, it is important to leave the valve between the syringe pump and the reactor open and set the syringe pump to be in constant pressure mode.

During reaction, CO_2 in the solution can be consumed and thus CO_2 can be continuously pumped into the reactor to maintain the set pressure. After reaction for different elapsed time (e.g., 3, 5, 8 , 17, 22, 44, 70 hrs and 6 days), the valve connecting the syringe pump and the reactor was closed to prevent further CO_2 injection into the reactor. Then the gas release valve of the reactor was open to release the CO_2. Meanwhile, the reactor was cooled down to room temperature.

After releasing the pressure and lower the temperature, the reactor was opened, the dissolved aqueous ion concentrations was analyzed by ICP-MS, to represent the biotite dissolution. The surfaces of the reacted biotite was analyzed by AFM, SEM, to study the surface morphology changes and secondary mineral formations.



rock/water ratio: 1 piece of biotite flake and 4 ml solution, 0.015 g/4 ml

Elapsed time: 3,5,8,17,22,44,70,96,120,144 h.

Figure 1: Single pump used to mimic GCS conditions

☑ *Note*

Experiments conducted in DI water were serving as a control. For clarification, all images shown in Figure 2 were collected after reaction in 1 M NaCl solutions at 95° C and 102 atm CO_2. Experiments were also conducted at lower temperatures. At 35° C the kinetics of illite formations slowed down, but illites formed at all temperatures.

Conclusions

As shown in Figures 2 and 3, the formation and mobilization of fibrous illite from biotite under GCS conditions can lower the permeability of the aquifer. So it may cause problems during CO_2 injection.

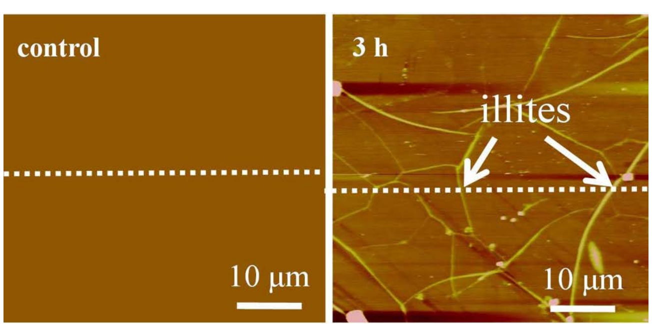
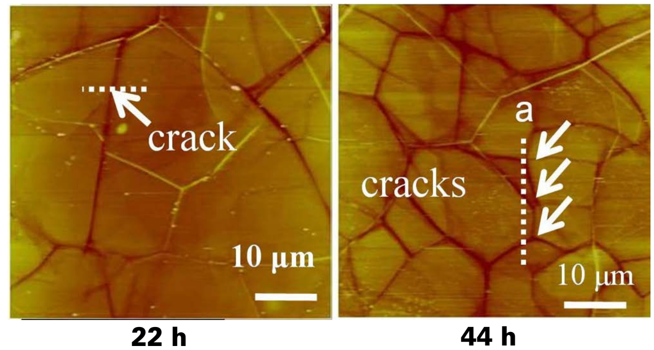


Figure 2: AFM observation of fibrous illite formation on reacted basal surface



Detachment of fibrous illite and biotite flakes from cracked surfaces

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