



Contribution ID: 389

Type: Oral Presentation

## Mineral reaction and salt precipitation on a chip: understanding aquifer-relevant geological processes during CO<sub>2</sub> injection

Thursday, 3 June 2021 10:15 (15 minutes)

Geologic CO<sub>2</sub> sequestration into deep saline aquifers is one strategy to reduce global atmospheric CO<sub>2</sub> levels. Injectivity plays a key role in determining the storage capacity of aquifers. During CO<sub>2</sub> injection into an aquifer, acid dissolution of carbonates arises due to CO<sub>2</sub>-acidification of formation water, enhancing permeability and connectivity. While salt precipitation within the brine-saturated porous media occurs as saline water is evaporated by injected CO<sub>2</sub>, severely reducing aquifer porosity and permeability. In turn, changes in pore structure and surface composition resulted from geochemical reaction and salt precipitation will alter the porosity, permeability and capillary pressure for the two-phase flow, changing the phase distribution of CO<sub>2</sub> and saline. Understanding the interaction of mineral reaction, salt precipitation and multiphase flow on the pore-scale is essential in order to assess and optimize carbon sequestration efforts.

To date, there have been a number of pore-scale experimental studies concerning mineral reaction or salt precipitation. While these various experimental studies can provide some insight into mineral precipitation and dissolution kinetics or salt precipitation dynamics, most of them are conducted at ambient conditions, which are not representative of real reservoir conditions. Moreover, few studies consider the complex interplay of mineral reaction, salt precipitation and two-phase flow.

In this paper, pore-scale visualization experiment containing CO<sub>2</sub>-water two-phase flow, geochemical reaction and salt precipitation has been conducted at typical formation temperature and pressure. A micromodel with real rock structure coated by calcium carbonate (CaCO<sub>3</sub>) and saturated with brine is used to resemble the saline aquifer composed of quartz and carbonate.

The functionalization of micromodels with CaCO<sub>3</sub> is accomplished by treating the glass micromodel with silane coupling agent and then alternately pumping CaCl<sub>2</sub> and Na<sub>2</sub>CO<sub>3</sub> solution into it. Raman spectroscopy and optical microscope are used to characterize coated micromodels. These results verify that the inner surface of the micromodel is covered with calcite particles of about 5-8 micrometers in size, and its hydrophilicity is enhanced compared with the original glass surface.

Then, the brine-filled micromodel is mounted on an inverted optical microscope to visualize the dynamic drainage processes using CO<sub>2</sub> of different flow rate at different temperature and pressure. SEM imaging is applied to analyze the resulting mineral and salt. We find that low CO<sub>2</sub> flow rate results in dissolution of CaCO<sub>3</sub> and salt accumulation occurs as there is enough time for ions to diffuse. Increasing the CO<sub>2</sub> flow rate can suppress the dissolution of CaCO<sub>3</sub> and capillary reflow of brine. This result means that the geochemical reaction between saline and rock can be hindered by the evaporation effect of high flow rate of CO<sub>2</sub> near the injection well and salt blockage is suppressed. As more water evaporates into CO<sub>2</sub> as it migrates in the aquifer, rock dissolution occurs because of formation of carbonic acid.

In summary, we take new insight into interaction of mineral reaction, salt precipitation and multiphase flow at pore scale, which provides a fundamental understanding of reaction and precipitation dynamics during CO<sub>2</sub> injection and paves way for future studies related to injecting more CO<sub>2</sub> in aquifers.

### Time Block Preference

Time Block A (09:00-12:00 CET)

## References

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**Session Classification:** MS1

**Track Classification:** (MS1) Porous Media for a Green World: Energy & Climate