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Understanding the impact of carbon mineralisation on the flow properties of basalts

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Permanent CO2 storage in basalts by means of mineralisation is a promising cost-effective way to achieving reduction of carbon emissions in view of climate change mitigation. CO2 is dissolved in water before injection in the subsurface, resulting in increased trapping safety, since solubility has already taken place. Storage of dissolved CO2 in basalts at shallow depth has additional advantages such as rapid mineralisation (1-2 years), reduced drilling and monitoring cost and lower risk of leakage and induced seismicity events. However, large-scale application of this storage technology would require substantial amounts of water making it not ecologially viable. The use of seawater as a solute is an ideal alternative that is explored since recently in Iceland. Recent studies on basalt-seawater-CO2 interaction showed that the efficiency of carbon mineralisation in seawater remains significant. Batch reactor testing revealed a total mineralisation of 20% of the initial injected CO2 within five months, corresponding to carbonation rates similar to those observed in basalt-freshwater-CO2 interaction experiments (lab and field).
Carbon mineralisation can substantially alter the pore space of the basaltic material, resulting in reduction of porosity, flow properties, and consequently overestimation of the injection and storage efficiency. While geophysical monitoring is not yet available, information on the reservoir properties of basalt remains limited. In this work, the impact of CO2 mineralisation on the hydromechanical properties of a basaltic sample is studied. For the first time, injection of CO2 dissolved in saline water is considered in view of a more ecological application of the technology at large scales. First, the flow properties of the material are measured in the lab before and after a 2-month exposure to dissolved CO2 under field-representative conditions. The experimental results show a permeability reduction of half an order of magnitude, suggesting porosity reduction due to mineral precipitation. Image analysis of x-ray tomographies of the tested sample before and after CO2 exposure show a total porosity reduction. To better understand the evolution of the pore network before and after mineralisation, pore network simulations are performed on the real 3D porosity of the material acquired from the x-ray images. Two types of porosity are considered, macro-pores and micro-pores (solid matrix porosity). Reduction of the size of macro-pores does not impact flow. To reproduce the post-exposure flow results, decrease of the solid matrix porosity is required, revealing that carbon mineralisation is more prone to take place in the micro-pores.

Participation

In-Person

References

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