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Laboratory scale investigation of CO2 flow mechanisms across clay-rich caprock

Wednesday, 2 June 2021 09:00 (1 hour)

Carbon capture and geologic storage, mainly in deep saline aquifers, is extensively considered as an essential component of any strategy to achieve carbon neutrality and effectively mitigate climate change. At pressure and temperature conditions relevant to CO2 storage in sedimentary formations, CO2 is less dense than the resident brine and tends to float, threatening the long-term storage operations [1]. Therefore, successful deployment of geologic CO2 storage relies on ensuring the sealing capacity of caprock overlying the host formation. Bringing together experimental methods and a numerical interpretation scheme, we aim at shedding light on the processes governing CO2 intrusion and flow through low-permeability shaly caprock. We perform CO2 injection experiments on Opalinus Clay samples retrieved from the Mont Terri underground rock laboratory in Switzerland. Two types of Opalinus Clay are examined: intact shaly specimen, representing an ideal caprock for CO2 storage, and remolded shale, representing the potential shear zone in the caprock [2]. The latter is found to possess higher intrinsic permeability and lower capillary entry pressure than intact rock. We parameterize a two-phase flow model in deformable porous media using appropriate hydromechanical properties and replicate experimental observations. Simulation results highlight three concomitant flow mechanisms: molecular diffusion of CO2, bulk volumetric advection of CO2, and brine advection transporting dissolved CO2. The bulk CO2 intrusion is confined to the lowermost portion of the specimen and remains unable to trigger an effective increase in the relative permeability of CO2. Therefore, advective CO2 migration is minor. We conclude that rapid capillary breakthrough of CO2 is unlikely to take place and compromise the sealing capacity of nonfractured caprock. The relatively slow diffusive flow appears to purely dominate leakage in the long term. Yet, diffusive CO2 leakage may occur over geological time scales and have to be assessed in field-scale tests and through numerical simulations.

Time Block Preference

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

References

1. Vilarrasa, V., Olivella, S., Carrera, J., Rutqvist, J. (2014). Long term impacts of cold CO2 injection on the caprock integrity. International Journal of Greenhouse Gas Control, 24, 1–13.

2. Makhnenko, R.Y., Vilarrasa, V., Mylnikov, D., Laloui, L. (2017). Hydromechanical aspects of CO2 breakthrough into Clay-rich caprock. Energy Procedia, 114, 3219–3228.

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Student Poster Award

Primary author: Dr RAHIMZADEH KIVI, Iman (Institute of Environmental Assessment and Water Research, Spanish National Research Council (IDAEA-CSIC), Barcelona, Spain)

Co-authors: Dr VILARRASA, Victor (Institute of Environmental Assessment and Water Research, Spanish National Research Council (IDAEA-CSIC), Barcelona, Spain); Prof. MAKHNENKO, Roman (Department of Civil & Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, USA)

Presenter: Dr RAHIMZADEH KIVI, Iman (Institute of Environmental Assessment and Water Research, Spanish National Research Council (IDAEA-CSIC), Barcelona, Spain)

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