Contribution ID: **192** Type: **Oral Presentation**

Trapping dynamics during geological carbon storage: Synchrotron time-lapse imaging of pore-scale capillary trapping events over the centimetre-scale in a heterogenous sandstone.

Wednesday, 1 June 2022 11:30 (15 minutes)

A major challenge for geological carbon storage is increasing confidence in storage security. The ability to model and predict trapping in complex geological systems is essential to minimise risks and ensure the permeance of geological carbon storage. Capillary trapping is a key mechanism shown to improve storage security by immobilising a significant proportion of the CO2 plume [1]. Current models predicting field-scale CO2 movement and trapping at several sites around the world do not fully capture the impact of heterogeneity on upscaled flow physics and trapping dynamics [2]. The aim of this work is to understand the effect of natural geological heterogeneities on the transient dynamics of the CO2 plume, and how CO2 is trapped dynamically in heterogenous sandstone aquifers.

State of the art synchrotron experiments at the Australian synchrotron (ANSTO) have been carried out, achieving combined spatial and temporal resolution not possible with traditional lab-based techniques [3]. Pore-scale trapping mechanisms were captured with a field of view over the continuum core scale (5cm), allowing us to investigate how larger scale capillary heterogeneity trapping processes are impacted by pore-scale events. Experimental observations resolving trapping over many pores, representative of the large-scale process, are crucial for model validation, development and ultimately storage predictions [2].

The time resolution achieved at ANSTO allowed us to capture unsteady state displacements, the prevailing conditions at most storage sites [2,4]. Unlike typical lab-based experiments which only capture steady state due to resolution constraints [3,5,6]. The core was imaged in 7 minutes, at a resolution of 20 microns, capturing pore-scale displacements dynamically. We observed the frontal advance and subsequent imbibition proceeding until the residual saturation was reached, gaining an understanding into pore-scale displacements and trapping dynamics. Both drainage and imbibition displacements were captured in a heterogenous Bentheimer sandstone core, representative of typical saline aquifer storage sites [7]. To date, there have been no direct observations of transient trapping in sandstones with realistic layered rock heterogeneities, features ubiquitous across proposed and operational storage sites worldwide. To evaluate the rate dependency of trapping, experiments over 2 different rates are compared to explore potential trapping within a range of carbon sequestration projects.

Geological heterogeneities impact the timescale and distribution of capillary trapping [6]. We observe the transient interaction of the fluids with an oblique layered heterogeneity –witnessing in real time how the non-wetting phase builds up behind the barrier, and eventually breaks through once the entry pressure is overcome. We see how heterogeneity impacts upstream pore-filling events, and subsequent imbibition, allowing us to quantify the path to residual trapping, and therefore, crucially, dynamic models. Natural heterogenous capillary pressure barriers trap the non-wetting phase at saturations greater than expected from pore-scale residual trapping processes alone, potentially providing greater CO2 storage capacity. Furthermore, injection rate impacts capillary trapping with lower rates of brine imbibition resulting in a greater proportion of capillary heterogeneity trapping, supporting numerical simulations [7]. The results from this synchrotron campaign demonstrate the potential impact of heterogeneity on the dynamics of capillary trapping within CO2 storage sites.

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References

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Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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