
Contribution ID: **167** Type: **Oral 20 Minutes**

# The impact of drainage displacement patterns and Haines jumps on CO2 storage efficiency

*Monday, 14 May 2018 10:05 (15 minutes)*

Injection of CO2 deep underground into porous rocks, such as saline aquifers, appears to be a promising tool for reducing CO2 emissions and the consequent climate change. During this process CO2 displaces brine from individual pores and the sequence in which this happens determines the efficiency with which the rock is filled with CO2 at the large scale. The aim of this work is to better understand the impact of different flow regimes, during immiscible two-phase flow, on the displacement and storage efficiency of CO2 deep in saline aquifers. Using multi-GPU free energy Lattice Boltzmann simulations we directly solve the hydrodynamic equations of motion on a three dimensional geometry reconstructed from micro-CT images of Ketton limestone and consider fluid flows in a range of capillary numbers Ca and viscosity ratios. We first verify the existence of the three typical fluid displacement patterns, namely viscous fingering, capillary fingering and stable displacement [1]. We examine how these distinctively different flow regimes can affect the displacement efficiency, defined here as the fraction of the defending wetting fluid that has been displaced from the pore matrix when the injected non-wetting phase reached the outlet of the domain. Continuing the injection beyond this point we establish the maximum displacement efficiency or storage capacity. Our results indicate that the maximum displacement efficiency decreases with decreasing Ca. As capillary fingering becomes the dominant displacement process at low Ca, storage efficiency converges to a limiting value irrespective of the viscosity ratio.

Particular focus is given to the low Ca flow regime, where displacements at the pore scale typically happen by sudden jumps in the position of the interface between brine and CO2, Haines jumps. We demonstrate that the method reproduces the expected features of the jumps, i.e. sharp increase in the non-wetting phase velocity, abrupt drop in the pressure signal and significant fluid rearrangement. We quantify the degree of fluid redistribution associated with these sharp events by identifying each event from the pressure signal. Preliminary results from this analysis suggest that pressure fluctuations and waiting times between the jumps follow an exponential distribution, in agreement with theoretical predictions, while the same also applies for the event filling volumes probably due to the extensive fluid redistribution. More importantly a significant decrease in storage efficiency is observed, irrespective of the direction of the jump relative to the overall flow direction, contrary to the arguments by Yamabe et al. [2]. This is due to irreversible fluid rearrangement during Haines jumps that alters the displacement pathways and renders regions of the porous rock inaccessible to the injected non-wetting fluid. This has important implications in the context of geological sequestration of CO2, as Haines jumps become a limiting factor in the storage process.

## References

[1] Lenormand, R., Touboul, E. and Zarcone, C., 1988. Numerical models and experiments on immiscible displacements in porous media. Journal of Fluid Mechanics, 189, pp.165-187.
[2] Yamabe, H., Tsuji, T., Liang, Y. and Matsuoka, T., 2014. Lattice Boltzmann simulations of supercritical CO2 - water drainage displacement in porous media: CO2 saturation and displacement mechanism. Environmental science & technology, 49(1), pp.537-543.

## Acceptance of Terms and Conditions

Click here to agree

**Primary authors:** Dr ZACHAROUDIOU, Ioannis (Imperial College London); Dr BOEK, Edo (Queen Mary University of London); Dr CRAWSHAW, John (Imperial College London)

**Presenter:** Dr ZACHAROUDIOU, Ioannis (Imperial College London)

**Session Classification:** Parallel 1-A

**Track Classification:** MS 3.11: fundamental aspects of geological storage of CO2