INTRODUCTION

Residual trapping is generally accepted as an important mechanism for immobilizing CO₂ and thus, contributing to storage efficiency and security. However, few studies have questioned whether trapping is permanent.

OBJECTIVE

The aim of this study is to examine the stability of residually trapped CO₂ at the pore scale by:

- Assessing the potential for Ostwald ripening to immobilize trapped CO₂ using synchrotron X-ray microtomography (micro-CT) analysis of pore-scale capillary pressure and modeling of Ostwald ripening mechanisms in rocks.
- Observing the evolution of residual CO₂ with time in a real rock by conducting a drainage-imbibition experiment with reservoir conditions and time-resolved micro-CT imaging.

MOTIVATION

Inter-bubble gas diffusion driven by pressure differences

- Laplace
- Henry
- Folk

\[ \frac{\partial P}{\partial t} = \frac{P}{\pi R^2} \]

\[ \frac{\partial P}{\partial t} = \frac{P}{\pi R^2} \]

\[ \frac{\partial P}{\partial t} = \frac{P}{\pi R^2} \]

\[ \frac{\partial P}{\partial t} = \frac{P}{\pi R^2} \]

\[ \frac{\partial P}{\partial t} = \frac{P}{\pi R^2} \]

EXPERIMENTAL APPROACH AND METHODS

- Air/water gravity driven imbibition
- Brine/CO₂ drainage-imbibition and repeated scanning
- 1D: pore space is a graph where edges are throats (conical)

What happens in porous media?

OSWALD RIPENING

- Inter-bubble gas diffusion driven by pressure differences

EVOLUTION OF RESIDUAL CO₂ FOLLOWING IMbibITION

- Inter-bubble gas diffusion driven by pressure differences

FLUID DISPLACEMENT

- Inter-bubble gas diffusion driven by pressure differences

Pore-scale modeling of Ostwald ripening in rocks

SIMULATION FRAMEWORK

Ostwald ripening mechanism is decoupled into two processes: internal equilibrium (fast) and mass-transfer (slow).

CONCLUSIONS

- Residual CO₂ in sandstones consists of disarticulated air ganglia localized in few pore bodies after imbibition. Their size and shape is controlled by the pore network.
- Gas ganglia may present noticeably different capillary pressures. Ostwald ripening may occur as a result but to a small extent for a given rock and with time scales of the order of magnitude of a year or less.
- A simulation framework to predict the evolution of systems governed by Ostwald ripening mechanism has been developed and is now being improved.

ACKNOWLEDGMENT

This work is supported by the Global Climate and Energy Project (GCEP) at Stanford and as part of the Center for Nuclear Combustion at Stanford (CNCS2), an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences under Award DE-SC0018121.

REFERENCES


Iglauer, S., and Pentland, D., Microtomography-based 2D: pore space is a graph where edges are throats (conical).