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EDITORIAL

Geologic CO_2 sequestration: progress and challenges

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1 Introduction

One of the most promising options to alleviate global warming is *carbon capture and storage* (CCS), a short- and long-term strategy for reducing atmospheric carbon dioxide (CO_2). CCS involves three stages: (a) capturing and compressing CO_2 emitted by industry; (b) transporting the CO_2 as a supercritical fluid; and (c) sequestering this fluid by injecting it in subsurface geologic reservoirs such as deep saline aquifers, or oil and gas reservoirs that are at least partially depleted (see Middleton et al. 2012). Of these, saline aquifers offer the largest storage volumes for CCS (DOE-NETL 2015); but CO_2 injection in hydrocarbon reservoirs is also of use for enhanced oil recovery (EOR) (Dai et al. 2014a, b, 2016).

The 2015 Paris agreement marks a new willingness by international leaders to collaborate on climate change mitigation. But the merit of the whole CCS program is still debated, because of recent instabilities in world politics, the scientific complexity of CCS, controversial environmental impacts from possible leakage, and uncertainties regarding cost (Bielicki et al. 2014; Bachu 2016).

Whatever further difficulties are to be overcome, improved understanding of CCS processes is a critical first step. Decision-makers, along with the general public, rightly demand assurances that the science, economics, and environmental risks of CO_2 capture, transport, and storage are fully researched. Only then can the safe sequestration of CO_2 be guaranteed, for thousands or at least hundreds of years; but so far, several pieces of the scientific puzzle are missing. Transport and trapping processes, dependent on solubility, residual, structural, and mineral factors, are not well understood. These encompass such complexities as multiphase flow, combined with chemical, thermal, mechanical, and biological interactions between fluids and the reservoir rocks (Benson and Cole 2008). In particular, oversimplified models and experiments leave us at risk of incorrect predictions for CCS's effectiveness. Several major questions challenge our research ingenuity. How are the

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processes controlled by interplay between large-scale flow patterns (such as fingering) and local-scale Fickian diffusion, mechanical dispersion, and chemical reactions? How can we incorporate small-scale processes (at pore and core scale) into large-scale flow and transport models? What are the implications of multiphase flow, and of thermodynamic changes in fluid properties, for the long-term behaviour of stored CO_2? How does the heterogeneity of rock–fluid properties, bringing its own elevation of uncertainties, impact the fate of CO_2 transport in storage reservoirs?

2 Scope of the special issue

Our special issue works to meet such challenges. We assemble recent developments in accurate modelling and sophisticated experimental approaches, which together will guide the design and implementation of geological CO_2 storage. Explicitly devoted to *Geologic CO_2 Sequestration*, the issue comprises contributions that advance our understanding of CCS processes, and our ability to assess environmental risks despite inevitable limitations in the data. We outline those contributions below.

1. Mixing and spreading of multiphase fluids in heterogeneous bimodal porous media by Amooie et al. (2017)
2. Performance assessment of CO_2-enhanced oil recovery and storage in the Morrow reservoir by Ampomah et al. (2017)
3. Effective constitutive relations for simulating CO_2 capillary trapping in heterogeneous reservoirs with fluvial sedimentary architecture by Gershenzon et al. (2017)
4. Evaluation of pressure management strategies and impact of simplifications for a post-EOR CO_2 storage project by Jia et al. (2017)
5. An object-based modeling and sensitivity analysis study in support of CO_2 storage in deep saline aquifers at the Shenhua site, Ordos basin by Nguyen et al. (2017)
6. Dynamic reduced-order models of integrated physics-specific systems for carbon sequestration by Sun and Tong (2017)
7. Modeling plume behavior through a heterogeneous sand pack using a commercial invasion percolation model by Trevisan et al. (2017)
8. Reactive transport modeling of arsenic mobilization in shallow groundwater: Impacts of CO_2 and brine leakage by Xiao et al. (2017)
9. Soil gas dynamics monitoring at a CO_2-EOR site for leakage detection by Yang et al. (2017)

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