Transport in Geologic CO₂ Storage Systems

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With atmospheric CO₂ concentrations accelerating, the need increases for deep reductions in CO₂ emissions from fossil-fuel combustion and other industrial sources. One approach for direct reductions of anthropogenic emissions that has received increasing attention over the past 10 years is carbon capture and storage (CCS). CCS involves two distinct technology areas: (1) CO₂ capture and (2) geologic CO₂ storage, also known as geologic carbon sequestration (GCS). While capture typically involves engineered extraction systems, implemented above-ground at power-generating stations and other industrial facilities, geologic storage involves deep underground natural systems, with attendant uncertainty and variability. Over all scales, and by multiple processes, transport within the porous formation, or in fractures, is the critical process at the heart of GCS safety, effectiveness, and environmental impact.

This Special Issue of TIPM is devoted to research results addressing key transport questions related to GCS, such as

- (1) What are the rates and styles of migration of injected CO₂?
- (2) How much of the injected CO₂ is trapped by the various trapping mechanisms?
- (3) What happens to in situ fluids that are displaced when CO₂ is injected?
- (4) What processes and features control CO₂ injection in deep and shallow subsurface formations?
- (5) How does coal respond to CO₂ injection?

The papers collected here need no individual introductions. Collectively, they serve to meet the goal of this Special Issue, which is to present cutting-edge research results that frame the current understanding of transport and related processes in geologic storage systems from basin scale to pore scale. The papers span a wide range of approaches, from modeling using semi-analytical solutions, reservoir simulation, and cutting-edge lattice-Boltzmann methods, to theoretical treatments and to laboratory experiments.

Work reported here demonstrates that GCS research has matured and expanded over the past decade, away from fundamental studies of capacity and general feasibility, and toward

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more detailed studies of processes and quantification of effects and impacts. Research, such as that reported here, is helping to build the foundation of knowledge needed to encourage the kinds of large-scale field tests and demonstrations that can show how to carry out GCS as a safe and effective approach to reducing CO₂ emissions at scales with material impact on climate change mitigation.