frontiers | Frontiers in Energy Research

TYPE Editorial
PUBLISHED 14 November 2023
DOI 10.3389/fenrg.2023.1333023



OPEN ACCESS

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RECEIVED 04 November 2023
ACCEPTED 08 November 2023
PUBLISHED 14 November 2023

CITATION
Liu S, Li H, Zhang Y, Ren B and Sun Q (2023), Editorial: CO2 geological storage and utilization (CGSU).
*Front. Energy Res.* 11:1333023.
doi: 10.3389/fenrg.2023.1333023



# Editorial: CO2 geological storage and utilization (CGSU)

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KEYWORDS

**CCUS, CGSU, geologic carbon storage, adsorption, density-driven convection**

Editorial on the Research Topic
CO2 geological storage and utilization (CGSU)

Massive anthropogenic CO2 emissions have been causing global warming, extreme weathers, and environmental problems. CO2 capture, utilization and storage (CCUS) have been regarded as one of the vital approaches for reducing CO2 emissions and achieving "carbon neutrality" goals. CO2 geological storage is considered an effective and safe approach for long-term CO2 storage by injecting CO2 into subsurface formations. Moreover, CO2 geological storage and utilization (CGSU) with enhanced subsurface energy and fluid extraction makes it more attractive considering the revenue from oil, natural gas, coal-bed methane, geothermal energy, and brine production. The associated trapping mechanisms of CO2 are different in various subsurface formations such as saline aquifers, oil/gas reservoirs, unmineable coalbeds, and unconventional reservoirs (hydrate, shale). A good understanding of multiphase flow, reactive transport, and energy/heat transfer of CO2 and subsurface fluids in these porous media is needed to guide the applications of CCUS.

To bridge the gap, a Research Topic on this topic is organized to bring cutting-edge research and advanced technologies of CGSU. Five up-to-date papers on innovative research, opinion and review on CGSU are showcased around the Research Topic.

In this Research Topic, Albertz et al. shared their review and perspectives on CGSU. The authors proposed that some elements, such as reservoirs, seals, and traps, are required for both successful CO2 storage and petroleum systems, but migration pathways and timing are not important for CO2 storage. This is because CO2 storage involves injection into a geologic trap rather than withdrawing fluid from a trap. Numerous petroleum traps, as well as naturally occurring CO2-producing fields and natural gas storage sites attest that safe and long-term CO2 storage is possible. Five main methods of geologic carbon storage have been validated through several demonstration and pilot projects around the world: 1) storage in depleted oil and gas fields, 2) use of CO2 in enhanced hydrocarbons recovery 3) storage in saline formations/aquifers, which is the greatest volumetric potential for CO2 geological storage, 4) injection into deep unmineable coal seams, and 5) *in-situ*/*ex-situ* carbon mineralization.

The interaction mechanism between shale and CH4/CO2 is crucial for CO2 sequestration with enhanced shale gas recovery, and the clay minerals are one of the key factors. Hui et al. conducted a fundamental study on the adsorption behaviors of methane and carbon dioxide on typical clay minerals by employing the molecular simulation method. The authors investigated the adsorption behaviors of both $CO_2$ and $CH_4$ on montmorillonite, illite and kaolinite under dry conditions by Grand Canonical Monte Carlo (GCMC) simulation. They found that the maximum adsorption capacity of single-component gas is associated with the types of clay crystals, and adsorption capacities are different for $CO_2$ *versus* $CH_4$. These discrepancies are caused by the characteristics of adsorbate molecules as well as the different structures of clay crystals. In addition, the studied clay minerals tend to preferentially adsorb $CO_2$ rather than $CH_4$ during binary gas mixtures simulation, and the cation exchange significantly enhances the electrostatic interaction with $CO_2$ molecules, leading to a higher loading of $CO_2$ as well as larger value of selectivity.

Dissolution trapping stands as a critical mechanism for geological carbon storage and can be notably improved through density-driven convection. Liu and Yao conducted a numerical study on the density-driven convection of $CO_2$-$H_2S$ mixture in fractured and sequential saline aquifers. The authors investigated the impact of $H_2S$ concentration, fractures, and lithology sequence on convective mixing, and found four distinct mechanisms influence the convective mixing in the fracture. The density-driven convection was enhanced with decreasing $H_2S$ concentration and increasing fracture interaction angle and fracture conductivity ratio, and it was significantly affected by lithology sequences. In addition, the authors demonstrated that the $H_2S$ concentration affects the flow direction within fractures and alters the relative magnitude of the dimensionless concentration in the noise sequences.

Zhang and Huang conducted a study on multicomponent composite anti-corrosion cement slurry system for solving acid gas corrosion problems such as $CO_2$ corrosion. In ultra-high temperature condition, the gas channeling problem in the cementing of acid gas wells cannot be ignored, which increases the difficulty in the design of anti-corrosion cement slurry system. The authors use hydroxyapatite blast furnace slag and functional temperature resistant and anticorrosion composite emulsion as anti-corrosion additives to build a multicomponent composite ultra-high temperature anti-corrosion cement slurry system with good engineering performance. They also analyzed the density, microstructure and phase composition of the anti-corrosion cement slurry, and discussed the corrosion inhibition mechanism of multicomponent composite cement paste.

Kang et al. focused on study on permeability characteristics of tight oil reservoir in Changqing Oilfield through high-pressure mercury injection. The authors analyzed the pore radius distribution and permeability contribution of the tight oil reservoir core. They found that the pore radii of the cores was in the range of 0.0040 μm–0.2500 μm, and the permeability contribution rate was basically positively correlated with the pore radius. The pore radius with larger contribution rate to permeability was concentrated between 0.0630 μm and 0.1600 μm with contribution rate of 79.53%.

We hope that readers will find the collective papers of this Research Topic to be useful references for the future research in the field of CCUS and beyond.

## Author contributions

SL: Conceptualization, Project administration, Resources, Writing–original draft, Writing–review and editing. HL: Writing–review and editing. YZ: Writing–review and editing. BR: Writing–review and editing. QS: Writing–review and editing.

## Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The authors greatly acknowledge the financial support of National Natural Science Foundation of China (Nos. 52374063 and 52074337).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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