

On-site gas monitoring of the Long-Term CO₂ Injection Experiment for CCS application

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For effective CO₂ underground storage, ensuring the integrity and sealing capacity of caprock is critical to preventing potential CO₂ leakage into overlying geological formations, the biosphere, or the atmosphere [1]. The CO₂ Long-term Periodic Injection Experiment (CO₂LPIE) investigates the hydraulic, mechanical and chemical effects of CO₂ injection into the sandy facies of Opalinus Clay (OPA) under in-situ conditions at the Mont Terri Underground Rock Laboratory, St-Ursanne (Jura, Switzerland) [2,3]. Given its geological properties, the sandy facies of Opalinus Clay serves as a global proxy for caprocks, making the insights on caprock behavior and integrity gained from this experiment broadly applicable.

Despite the importance of caprock integrity, most research in this field has been conducted at the centimeter scale, which fails to capture the complexities of large-scale heterogeneity in natural formations. Data at scales exceeding meters, which are more representative of real-world conditions, are still lacking. The CO₂LPIE in-situ experiment bridges this gap by providing high-resolution, large-scale experimental data, contributing to a more comprehensive understanding of CO₂-rock interactions and the long-term integrity of geological storage sites.

To meet this goal to geochemically track the evolution of the injected gases (CO₂, Kr, Ne) within the rock volume, we developed a novel gas injection method along with an on-site gas monitoring station. These new injection and monitoring techniques will allow for long-term CO₂ tracking, providing new insights into gas transport within the caprock. We will present these innovative methodologies, highlighting their role in advancing CO₂ sequestration research and in ensuring the safety and viability of future geological storage sites.

[1] Kaldi et al. (2013) *Energy Procedia* 37, pp. 5403–5410.

[2] Sciandra, D. et al. (2022). *Geomechanics and Geophysics for Geo-Energy and Geo-Resources* 8.5, pp. 1–19.

[3] Rebscher, D et al. (2020). *Technical report*. DOI: 10.1007/s11242-020-01484-z.