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Remediation of CO2 Leakage from Deep Saline Aquifer Storage Based on Reservoir and Pollution Engineering Techniques

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SUMMARY

The need to know what can be done in case of abnormal behaviour of the CO2 storage reservoir has been outlined by various regulation frameworks on CCS operations. Therefore, a proper risk management scheme should include a remediation plan to demonstrate that any undesired consequences can be corrected.
The available remediation measures mainly stem from the field of pollution engineering and of oil and gas industry. But due to the uniqueness of CO2 geological storage activities (time and spatial scale), the extent to which such measures can be used, if not adapted, for CO2 storage in deep saline aquifers should be investigated. We adopt the global framework of the source - transfer - target approach in case of an accidental CO2 leakage from the reservoir (either through faults or through abandoned wells). At each stage of the approach, the feasibility of the remediation measures is assessed based on large scale multiphase fluid flow transport simulations using TOUGH2 (LBNL).
At the source level, the proposed intervention strategy relies on the pore pressure control of the reservoir. The injection of CO2 at an industrial scale is simulated using a large scale model of the Dogger layer in the Paris basin. Once an irregularity has been detected, the first corrective action is to stop injection leading to the aquifer pressure recovery. We show that the overpressure in the injection zone rapidly decreases and it can be strongly accelerated by fluid production directly at the CO2 injection well. Nevertheless, lowering pressure at a larger distance from the injection zone requires the creation of an additional production well.
Considering the transfer component, we propose an intervention strategy based on the creation of a hydraulic barrier, which consists in injecting brine in the overlying aquifer to prevent the CO2 leak from vertically migrating through the leakage pathway. Results of the parametric simulations (injection rates, local conditions) show that this technique can be efficient, but might be at the cost of large over-pressure.
At the target level, we define a synthetic shallow freshwater aquifer based on the Paris basin case. We investigate the feasibility to rely on natural processes without human intervention to both reduce the mass of mobile accumulated CO2 and the concentrations of potentially releaseable trace elements. We show that the natural attenuation is characterized by very large time scales, hence requiring the combination with more active intervention procedures (e.g. pump and treats techniques).