The role of geological processes on long term CO_2 storage security in aquifers

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Geological CO_2 storage is an important transitional technology to limit global warming to 1.5C (IPCC 2005). CO_2 is injected into underground porous and permeable sediments containing saline water with the intention that it will remain trapped there for thousands of years. Ideally these saline aquifers have good communication over 10s of km to reduce pressure buildup during injection. However, this makes it more likely that the aquifer water is flowing naturally. This flow is driven by natural processes such as ongoing meteoric recharge (rainfall), basin uplift or subsidence or past petroleum production. CO_2 injection will modify the direction and rate of this hydrodynamic flow.

Previous work[4] has shown that steady state aquifer flow can alter the CO_2 storage capacity in an aquifer during structural trapping. Aquifer flow can tilt the CO_2-water contact increasing or reducing the likelihood of spilling. Woods and Espie (2012)[5] showed that aquifer hydrodynamics may also improve the rate of dissolution trapping because aquifer flow results in the removal of CO_2-saturated water from underneath the CO_2 plume. This may subsequently increase the amount and rate of mineralisation, increasing trapping security.

Further research is needed to determine the impact of changing geological processes over time on aquifer flows and thus CO_2 storage security, including possible impacts due to climate change. Global warming is likely to increase sea levels and melt the ice caps. Both of these processes may alter the flow dynamics in underground aquifers. Some aquifers are directly connected to the seafloor so their pressure regime will be modified by increasing sea depth. The UK is already undergoing glacial unloading following melting of the ice sheets after the last ice age, which in turn is slowly altering the pressure field in the subsurface.

This project will develop a workflow and algorithms to integrate hydrogeologic, basin and reservoir modelling approaches to enable resolution of the movement of CO_2 within the aquifer, model the dynamics of aquifer flow and evaluate its impact on long term storage security. Based on this, methods for mitigating any adverse impacts will be proposed. The project would suit anyone residing in the UK with a first degree in any quantitative science or engineering discipline.