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DETECT - Determining the risk of CO_2 leakage along fractures of the primary caprock using an integrated monitoring and hydro-mechanical-chemical approach

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In order to verify and demonstrate successful long-term CO_2 storage to the regulators and the public, it is critical to improve our understanding of leakage from CO_2 storage reservoirs along natural pathways. Currently, there are significant gaps in the general understanding of fluid migration along fault zones and fracture networks of the primary caprock. Leakage rates depend on pressure gradients, fluid densities, fluid saturations, and the flow properties of the fracture networks, which are a complex function of fracture density, connectivity, aperture size and stress regime. The fluid flux is affected by physical and chemical interactions taking place in the fracture system, including mineral dissolution and precipitation, swelling or shrinkage of clay minerals or hydro-mechanically driven propagation of new fractures. These combined effects can result in an increase or decrease in fracture network connectivity and permeability over different temporal and spatial scales. The combination of all these aspects is challenging and although some fundamental laboratory or modelling studies are available in the literature, an integrated study, involving a complete life cycle risk assessment of CO_2 leakage along fractures in caprocks is lacking. Added complexity is given by the fact that a leak can only be detected and quantified when geophysical or chemical monitoring tools are able to distinguish relevant changes in gas saturation, pressures or compositions compared to baseline levels.

DETECT, cofunded by the ACT program of the European Union and national governments, intends to determine realistic flow rates and geometries across fractured and faulted caprocks, and aims to identify monitoring tools capable of detecting such fluid migration. For this purpose, predicted monitoring performance of state-of-the-art technologies will be compared with results from coupled hydro-mechanical flow and reactive transport simulations which in turn have incorporated insights from a comprehensive laboratory study.

This improved understanding of the potential flow rates will feed into an integrated life cycle risk assessment using the established bowtie method to provide an overall picture of the natural paths via which CO_2 leaks could occur from subsurface storage reservoirs. The bowtie model will be expanded to include quantitative risk assessment, with the goal of calculating the probability/likelihood of leakage across the caprock and estimating the risk reduction provided by monitoring.