Abstract

Estimating Across-Fault Leakage Rates and their Financial Implications for CCS with Application to Offshore Gulf of Mexico

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Faults can help contain CO_2 within a storage reservoir, but they may also provide a leakage path under certain conditions. Conventional petroleum fault seal analysis tells whether a fault seals or leaks over geologic timescales. Quantification of the rate of a potential leak is an essential and largely missing component in CCS that places the leakage risk between the "leak"- "no leak" end-members in human timescales. Leakage rate quantification aids project permitting, informs monitoring plans, reveals containment efficiency, and supports financial investments. In the present study, we create an algorithm to estimate across-fault leakage rates of CO_2. We use petroleum industry fault seal analysis plus application of Darcy's law to the areas on the fault with the highest leakage probability. We then transform the rates to cumulative leaked masses and perform Monte Carlo simulations to bracket the rates according to fault attribute uncertainties.

We illustrate the algorithm with a model of a double fault-bounded storage prospect in the offshore northern Gulf of Mexico shelf. We tested the algorithm for 40 years of injection at a rate of 0.7 $MtCO_2$. If the injector is placed 1 km away from the faults, the cumulative leaked masses of CO_2 are between 137.19 and 7,408.93 $ktCO_2$ for open and closed boundary conditions respectively (or between 0.49% and 26.46% of the injected total). It is conservative and likely more realistic to assume the reservoir's boundaries are semi-closed. In this case, simulations output between 372.03 and 570.24 $ktCO_2$ of leakage with 90% confidence. Our results suggest that in similar GoM settings with abundant shales, the fault core permeability and thickness should be favorable for sealing. However, they can exhibit 3 and 1 orders of magnitude of variation

respectively and thus should be modeled as uncertainty distributions. We found that pressure and area of highest-leakage-probability are the critical drivers of leakage rate. The net present value of an injection project into the GoM trap varied from $52.32M to $63.02M depending on the scenario of estimated leakage rates. This result indicates that leakage quantification is key in financial viability of CCS projects.

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