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The Otway CCS Fault injection experiment: Fault analysis

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Abstract

Net zero subsurface technologies, such as carbon capture and storage, depend on a secure subsurface containment system, preventing injectants from migrating back up towards the surface and into the atmosphere. One major geological factor known to affect containment is the presence of geological faults that cut through the earth's crust. Our current understanding of how faults influence fluid migration behaviour in sedimentary basins is largely based on the operational experiences of the oil and gas industry that mostly deal with normal faults, due to the predominance of extensional tectonics in many oil and gas environments. Various workflows have therefore been developed for normal faults which allows estimation of their hydraulic properties and more specifically their potential leak points.

Conversely, many CO_2 projects around the world are actually located onshore in stress regimes that are strike-slip in nature, where the fault plane is near vertical and movement is lateral. Even if the faults in the deeper portions of the basins are extensional, shallower faults are often strike-slip in nature or reverse which is partly a result of surface rocks being less dense, thereby reducing the importance of the vertical stress that drives normal faulting. Contrary to normal faults, it is often difficult to determine the magnitude of displacement on strike-slip faults and there are currently no algorithms that can be used to determine the sealing behaviour of such faults. To address some of the uncertainties surrounding CO_2 behaviour near strike slip faults, a controlled release injection experiment is being planned at the CO2CRC Otway International Test Facility, which has been used for over 15 years to conduct a variety of CO_2 injection experiments. In 2016, a high resolution shallow seismic survey identified a shallow sub-vertical fault extending down to about 450 m, later named the Brumbys Fault. Two wells have been drilled and a significant amount of data collected on the fault and surrounding rock (geomechanical, resistivity, geochemical).

Numerous dynamic modelling scenarios have been conducted using two different modelling packages, so that the subsurface and fault-related gas flow could be characterised. The modelling indicates that significant differences in plume behaviour will occur depending on the depth of the injection experiment and also on the permeability that is attributed to the fault. In the case of high fault permeability (500 mD), both GEM and TOUGH results show rapid CO_2 migration up the fault to the base of overlying clay layer. The CO_2 plume reaches the top of the model within a

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week and appears to spread out along the fault under the clay layer. Conversely, when the fault permeability is low (50 mD), it is predicted that the CO2 will remain largely trapped in the injection interval and will not reach the upper clay layer.

Recent core analysis using a high resolution permeameter and high resolution X-ray tomography indicate that the fault is more likely to have a permeability close to that of the high permeability scenario. In fact, some measurements suggest the fault may possess a permeability in excess of 500 mD. The implication is that there is a real possibility that CO_2 will effectively flow up the fault on relatively short time scales. However, models show that the flow up the fault is also highly dependent on the permeability of the reservoir rock in contact with the fault, as it plays a key role in delivering CO_2 to the fault. In this talk we will present the most recent X-ray tomography results and discuss how they are likely to affect gas flow following injection.

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