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Controlled CO2 Release Experiment into Brumbys Fault: Fault Characterisation

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Summary

Not Provided

Introduction

In early 2024, a novel field trial will be conducted at the CO2CRC Otway International Test Centre, in which a small volume of CO_2 will be injected into a shallow fault and monitored using various techniques. The planned experiment is designed with the goal of better understanding how a CO_2 plume might interact with shallow faults about a CO_2 storage reservoir, and also develop monitoring strategies that can help provide assurances to stakeholders and the public regarding future CCS projects. The experiment will occur in the Port Campbell Limestone sequence, which is a Miocene aged carbonate sequence that outcrops over much of southern Victoria.

The fault involved with the 2024 injection test has been named Brumbys Fault, and was identified in 2016 from a high resolution shallow seismic survey. The fault extends from the surface down to about 450 m, and can be traced for about 1 km laterally. In 2019, two wells were drilled (Brumbys 1 and 2) with the purpose of detailed data collection on the fault and surrounding rock (geomechanical, resistivity, geochemical) so that accurate modelling and planning could be conducted for the controlled release experiment. This paper details the properties of the fault and surrounding lithologies and presents results of dynamic simulations performed in advance of the experiment.

Fault Characterisation

Recent core analysis using a high-resolution permeameter and high resolution X-ray tomography indicate that the fault is likely to have a permeability of about 500 mD (Tenthorey et al., 2022). The implication of this result is that there is a likely possibility that CO_2 will effectively flow up the fault on relatively a short time scale. However, dynamic models discussed below 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 migrating CO_2 to the fault.

Results from triaxial tests show that the intact rocks surrounding the Brumbys fault are weak, exhibiting a ductile behaviour with no peak stress at which sample failure occurs. The behaviour of the samples under triaxial conditions suggests that the tensile strength of the rocks is likely to be very low. Given this situation, the only parameters working against mode 1 tensile failure of the rock during injection are the magnitudes of the three principal stresses, the lowest of which is in the horizontal plane and is 14 MPa/km. Direct shear testing of rocks from the fault zone indicate commonly observed frictional values of between 0.65-0.75, which are positive for fault stability. However, on the flip side, fault cohesion is likely to be low as is that for the intact rock. The fault should therefore be considered as moderately weak and cohesionless.

Numerous dynamic modelling scenarios were conducted using two different modelling packages, so that the subsurface and fault-related gas flow could be characterized (Feitz et al., 2022). 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 (Hesse Clay). The CO_2 plume reaches the top of the model within a 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 CO_2 will remain largely trapped in the injection interval and will not reach the upper clay layer.

2024 Experiment

Currently, the design of the injection test involves 10 tonnes of CO_2, injected at about 80 m deep, into a high permeability layer. Two new wells (Brumbys 3 and 4) were drilled in late 2022, which will be used as an injector and monitoring well, respectively. An illustration showing the location of the 4 wells can be seen in Figure 1. The monitoring techniques will include high temporal resolution 4D reverse seismic profiling and downhole distributed temperature and strain sensing using fibre optics.

The Brumbys controlled experiment and the pre-injection characterization and modelling presented here simulates how an unwanted leak of CO_2 might interact with a shallow fault and manifest itself at the surface, and therefore provides information on how to monitor for leaking CO_2.

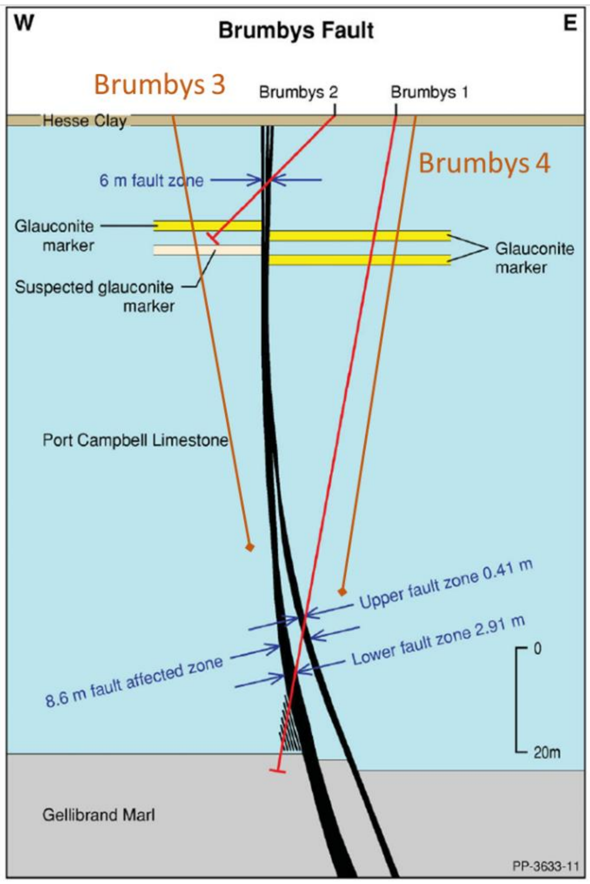

Figure 1. Schematic illustration of controlled release CO_2 experiment to be performed at the OITC in early 2024. Brumbys 1 and 2 wells were drilled in 2019 and were used for detailed fault and site characterization. Brumbys 3 and 4 which were drilled in 2022 will be used for injection and monitoring. Brumbys-4 is deviated away from the page and Brumbys-1 (towards north).

References

Feitz, A. et al., (2022). The CO2CRC Otway shallow CO2 controlled release experiment: Fault characterization and geophysical monitoring design, International Journal of Greenhouse Gas Control, Volume 118, 2022, 103667.

Tenthorey, E., et al. (2022) The Otway CCS Fault Injection Experiment: Fault Analysis. Proceedings of the 16th Greenhouse Gas Control Technologies Conference (GHGT-16) 23-24 Oct 2022,