In Situ Laboratory: Collaborative Investigation of the role of faults in the CCS context

Storing carbon dioxide in deep geological formations, known as Carbon Capture and Storage (CCS), can help reduce atmospheric emissions and support the transition to lower-emission industries. At the In-Situ Lab research facility, the CSIRO and RITE are investigating crucial CCS monitoring technology and systems to provide science-based evidence to support the development of cost-effective, reliable and safe CCS projects.

Australia and Japan are working together to achieve a net-zero emissions future through the Japan-Australia Partnership on Decarbonisation through Technology. Harnessing the strengths of both nations in developing and deploying advanced decarbonisation technologies, highlighting the shared commitment to reducing greenhouse gas emissions and promoting sustainable development globally.

Carbon Capture and Storage near fault systems

Geological carbon storage projects initially aim to avoid fault systems to minimize migration risks. However, as these projects grow, encounters with faults become more common, requiring a better understanding of CO_2 interactions with these geological features.

To address this challenge effectively, it is crucial to thoroughly characterise, forecast and monitor the potential impacts of interactions on the integrity of CO_2 storage sites. The development of advanced methods to address and reduce associated uncertainties will become increasingly critical. Affordable and reliable monitoring systems to detect and manage residual risks will be essential for ensuring the long-term safety and success of geological carbon storage initiatives. This comprehensive approach will help maintain the reliability of storage solutions and support broader efforts in reducing greenhouse gas emissions.

The In-Situ Laboratory Research Facility

The CSIRO In-Situ Laboratory (ISL) Research Facility, located near Harvey, 140km south of Perth, is a cornerstone for advancing this CCS research topic. The ISL was created in 2019 with the specific purpose to study fault systems and to assist the development of technologies for detecting and monitoring the migration of fluids in such systems.

The ISL is collocated with a major fault structure which was identified by seismic and well drilling. In 2019, a first shallow gaseous CO_2 controlled release test (Michael et al, 2020) was conducted at shallow depth. Since 2020, the research facility was significantly instrumented both at surface and downhole with a range of geophysical and geomechanical monitoring and verification systems.

The RITE – CSIRO partnership

Since 2022, the Research Institute of Innovative Technology for the Earth (RITE) and CSIRO have developed a pivotal collaboration for advancing carbon capture and storage technologies, with a particular focus on understanding fault systems and their impact on CO_2 storage. RITE is a Japanese research organization focused on developing and promoting advanced technologies for environmental conservation and sustainable development, including carbon capture and storage. By working together, these esteemed organizations combine their expertise to investigate how faults and geological formations interact with injected CO_2 and demonstrate innovative monitoring technologies, a critical factor in ensuring the safety and reliability of long-term carbon storage. This collaboration enables more precise modelling and management of fault-related risks, resulting in improved techniques for mitigating potential leakage and enhancing storage reliability. Insights from this research are crucial for refining storage methods and developing robust monitoring systems, significantly contributing to global efforts to reduce greenhouse gas emissions and achieve climate targets.

Investigating fault systems

The aim of the RITE-CSIRO partnership is to demonstrate fault systems characterization and testing workflow at field scale through in-situ demonstrations focused with the F10 fault. In 2023, the RITE-CSIRO team installed new downhole geophones and tiltmeters and perform new seismic acquisition and processing related to the F10 fault characterization.

As critical structural uncertainties were identified from previous seismic datasets, 2 new 2D seismic lines were acquired and the existing 3D seismic survey was reprocessed in 2023. The new seismic data helped define structural features in the F10 hanging wall's top 500m, revealing a complex network of conjugate and synthetic faults representing an extended but low intensity damage zone loosely associated with F10.

A fit-for-purpose additional well doublet (Injection + monitor) intersecting the entire F10 fault zone is currently under drilling. The well doublet aims to inject formation water and CO_2 in the vicinity of the F10 fault zone to better understand the geomechanical and containment behaviour of the fault zone in the context of a CCUS project.

These experiments aim to develop and test operational fault risk assessment workflows and geomechanical monitoring strategies to de-risk fault systems.

The Harvey 6 monitoring well was drilled in early 2024 and instrumented with two specialized fibre optic sensing cables for monitoring purpose. Surveillance of the drilling, completion and cementing operations provided new insights on the F10 fault systems. Further drilling is planned in 2025 with additional monitoring capabilities.

Future experiments within the F10 fault zone aim to observe the behaviour of the fault during the injection of fluids (formation fluids and potentially CO_2) in the subsurface. The unique dataset will be crucial for evaluating the connectivity of the fault and assessing associated risks, while also allowing for the evaluation of the performance of various monitoring technologies.

Further research at the site is playing a critical role in the understanding and risk mitigation of faults systems. CSIRO communicates research to raise science-based awareness among local landowners and communities. The ISL serves as a long-term field site, supporting education, training, capacity building, and technology testing in the CCS sector, both domestically and internationally.

For further information

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