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Delivering Innovative Solutions for CCS Monitoring – CO2CRC Stage 3 Project Operations Summary

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Abstract

The Stage 3 experiment was conceived a decade ago based on a vision to deploy and field test a toolbox of innovative monitoring and verification (M&V) techniques and technologies for saline acquifer based CCS projects that are not only economical, but are risk based and fit for purpose, minimise impact to the environment and provide improvements in temporal resolution – which would be acceptable to the regulators and to the communities in which the projects were being conducted. Since the original vision, the project has evolved, gained momentum and definition, leading to the final investment decision (FID) which was taken by CO2CRC's Board in May 2019. The experience of the project – from the construction of the infrastructure to the acquisition of the data using both conventional and the innovative Stage 3 M&V technologies – will be presented in this paper, detailing why certain descisions were made and the challenges and highlights of the project leading to its successful conclusion in May 2021.

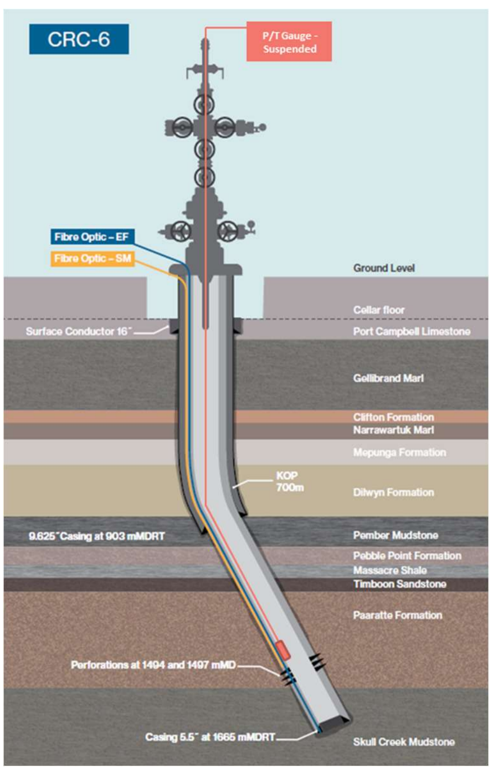
The Stage 3 Project focused on the trial of two primary monitoring techniques – pressure tomography and downhole seismic – but also tested other ancillary modalities such as earth tides, pressure inversion and passive seismic to better understand their application in an industrial context. The field trial – held at CO2CRC's Otway International Test Site (OITC), was based on the simulation of an industrial project through the small-scale injection of 15,000 tonnes of supercritical CO2 into a saline aquifer located 1650 m below ground – an approach that CO2CRC has used successfully in past demonstrations, notably the Stage 2C experiment conducted in 2016. The techniques were tested using four newly constructed monitoring wells and a single injection well – all completed with fibre optics and pressure monitoring equipment – combined with a number of permanent seismic sources (surface orbital vibrators, SOV's) located strategically around the site. The works to install this infrastructure commenced in mid-2019 and continued through to mid-2020, including the communications and data handling equipment required to receive, store and process the significant volumes of data generated each day, the gas pipeline required to deliver the CO2 to the injection well and the water distribution and injection system required to test pressure tomography in the field. By June, the works had been completed and the commissioning stages commenced.

Commissioning and baseline measurements started in March/April 2020 with the first 3D seismic survey collected for the site using the newly installed infrastructure. This and the subsequent surface surveys, using accepted, conventional technology was to provide the project benchmark against which the innovative techniques of pressure tomography

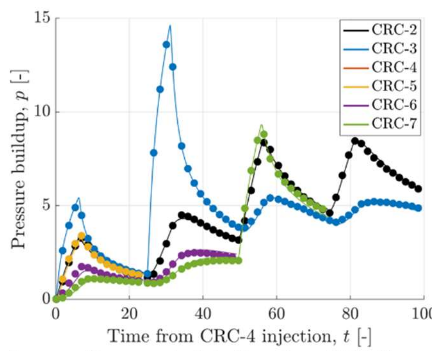
and downhole seismic would be compared. At this same time (and mid way through the survey), the Covid restrictions came into force in Australia and new ways of acquiring this survey remotely and with minimal field support, had to be developed. These restrictions persisted throughout 2020 and into 2021 affecting the remainder of all operations on site in support of the project. Baselines for the pressure tomography and downhole seismic were acquired in the second half of 2020, enabling an improved understanding of the techniques and equipment installed prior to the injection itself.

In December of 2020, the injection operation commenced at 50 ktpa of CO2 and for the next 5 months – through to April 2021 – the development of the plume was monitored using both conventional and innovative means. The lessons learned during this period regarding the utilization of the equipment, the performance of the wells, the deployment of assets and how and when data was retrieved and processed were all carefully noted and documented and used to improve the understanding of how these innovative techniques can be employed and optimised in industrial applications. Ultimately, the project successfully demonstrated the application of pressure tomography and downhole seismic with both modalities accurately detecting and locating the plume in the subsurface with unprecedented accuracy and temporal resolution when compared with the conventional seismic 3D benchmark. Both techniques were shown to provide results on demand, with little or no operator support – generating data automatically, which was largely autonomously processed on site with minimal offsite processing and quality control required to ensure accuracy. With detection limits shown to be as little as 300 tonnes for the downhole seismic and 4.5ktonnes for the pressure tomography, these innovative solutions for economically and accurately detecting the plume in the subsurface will have immediate applications to industry and help accelerate the adoption of CCS globally.

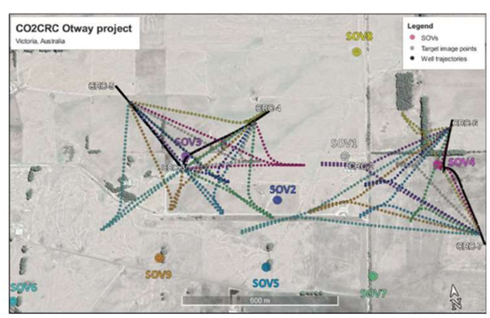
Keywords: CCS monitoring; pressure tomography; downhole seismic; timelapse; saline aquifers



Monitoring well at OITC, Victoria, Australia



Pressure Tomography injections from CRC4 through to CRC7 monitored downhole at all wells



Downhole Seismic equipment deployment showing monitor transects between SOV and monitoring wells