CCP

CCP PROJECT FACTSHEET

CONTINGENCIES PROGRAMME II – INTERVENTION TECHNOLOGIES
Development and testing of intervention technologies at Mont Terri Underground Laboratory

CONTEXT

In 2012, the CO_2 Capture Project (CCP) embarked upon an important initiative to address a frequently cited concern about CO_2 capture and storage – how to mitigate the risk of possible escape of stored CO_2 from its containment zone. This work has now culminated in a comprehensive testing programme.

Rigorous pre-injection site screening, operational monitoring and well sealing remain the most important safeguards to ensure secure, permanent storage of CO_2. However, the aim of the CCP Contingencies Programme was to build extra confidence by developing the capability to detect, characterize and intervene in unexpected migrations of CO_2 from storage zones.

Phases 1 and 2 defined the scope and modelled migration scenarios (see CCP Factsheet *Contingencies Programme),* prior to the development and testing of intervention technologies. For this, a site was identified at the Mont Terri Underground Rock Laboratory, Switzerland. The aim of this multi-year experiment was to develop long-term, novel sealant solutions for damaged well systems. These would focus on potential leakage pathways associated with micro annuli interfaces that can develop between casing, cement sheath and rock. Excavation of the entire casing, cement and surrounding rock by overcoring was planned to complete the experiment to understand sealant performance.

This work is now completed and forms the subject of this Factsheet. Full details will be available in the CCP4 Results Book on www.co2captureproject.org from Autumn 2022.

The Mont Terri Underground Rock Laboratory is located 300m underground in Jura Canton, north-west Switzerland. It provides an intermediate scale approach between the bench and the field to allow control of boundary conditions directly, and observation of large-scale rock mass-driven reactions that mimic full field scale conditions.

Partners of CCP in this project include Mont Terri Underground Rock Laboratory and SWISSTOPO (onsite logistics management).

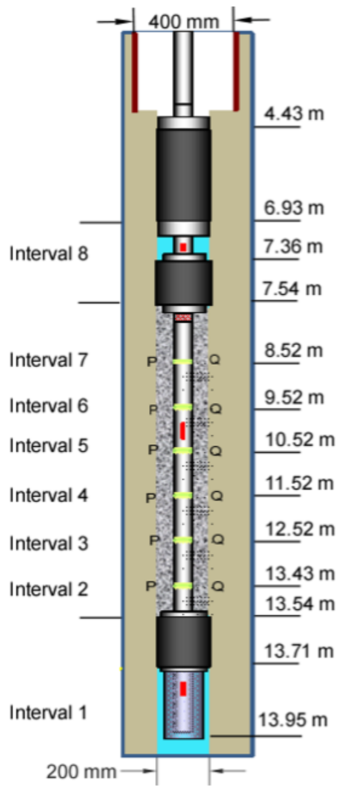
SET UP AND METHODOLOGY

An experimental borehole was designed to mimic cased and cemented interval de-laminations at the casing-cement and cement-rock boundaries, as well as fracturing within the cement sheath. It was drilled to a depth of 14.4m, consisting of a 400mm diameter pilot borehole to a depth of 4.26m in the upper part and a borehole of 200mm below that.

There were eight pressure compartments (intervals) within this, with interval 1 at the lower open hole injection level, and intervals 2-7 comprising the cased and cemented injection/extraction ports. Interval 8 was the uppermost open hole observation section.

A borehole packer system (top packer and two grout packers), three temperature sensors, injection lines and pressure sensor cables were also deployed.

The annulus between the upper and lower intervals was cemented, followed by saturation of the intervals. Two hydraulic tests were carried out and three heating cycles to create sufficient permeability conditions (i.e., microcracks) to proceed with sealant testing.



Set up of borehole and placement of instrumentation for test procedures.

A test procedure, involving a step rate pressures protocol, was employed to compare sealant performance, which allowed permeability to be assessed around each interval at different pressure levels. Injection of treated water was at 20, 25, 30 and 35 bar intervals for four minutes per step; and flow rates were compared at the end of each step.

Four sealants were selected for testing - each was injected sequentially in different interval(s), during the period September 2017- end 2019.

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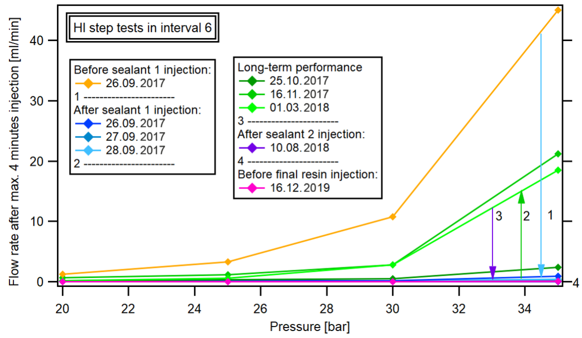

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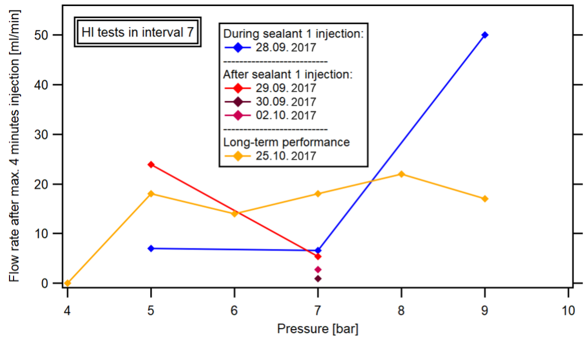

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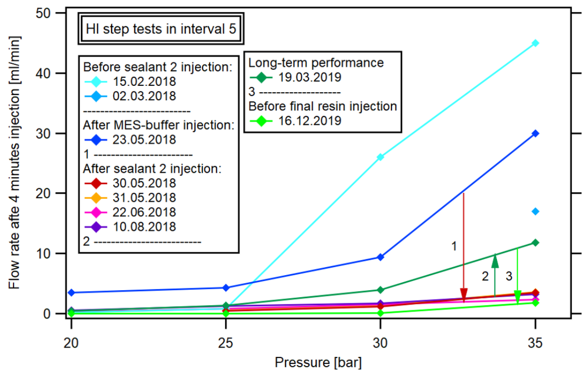

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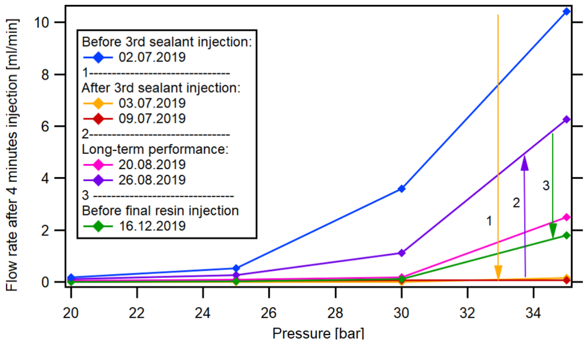

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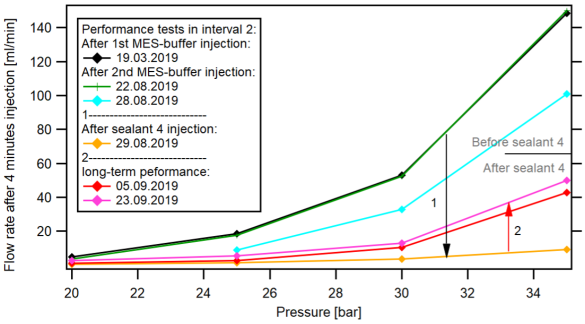

RESULTS SUMMARY

Sealant 1 - Nanoparticle Hydrogel sealant from Los Alamos National Laboratories

Multiple tests were carried out sequentially, which achieved good sealing up to 35 bar in the low permeability interval 6, but proved temporary in the much higher permeability conditions of interval 7. Success in the low permeability interval shows promise for providing a successful seal in reservoir environments. 1

Sealant 2 - Polymer Gel from University of Texas

Injected into interval 5, this sealant significantly reduced leakage rates, albeit not to zero, with flow reduced to 3 ml/minute at differential pressures of less than 30 bar. 2

Sealant 3 - Silicate-based sealant from IFP Energies Nouvelles

This sealant was injected into interval 4 and showed initial sealing up to 35 bar, with very low flow rates. The sealant then degraded with flow rates increasing after several days. 3

Sealant 4 - Epoxy-based sealant from University of New Mexico

Sealant 4 was injected into interval 3 (no performance tests possible) and then interval 2. It demonstrated excellent sealing performance directly after injection in interval 2. However, there was a noticeable decrease in sealing capacity after several days due to a short-distance connection between interval 2 and the observation interval 1. 4

POST OVERCORING AND COMPLETION OF THE STUDY

A final hydraulic test campaign was carried out after sealant injection was complete and revealed good sealing of the entire borehole, with all intervals demonstrating yield permeabilities similar to those of the Opalinus Clay host rock.

An attempt was made to overcore the entire well system to help understand questions around flow path geometry, penetration depth of sealants, interaction and degradation of sealants, cement and casing. The initial attempt using a double-barrelled machine at the main sealant zone at around 8m resulted in damage to the cement and shale; however, subsequent angled side drilling was successful and enabled recovery for analysis of cores around injection points. Full results will be made available at www.co2captureproject.org from Autumn 2022.

ABOUT THE CCP

The CCP is an award-winning group of major energy companies working to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage.

To find out more visit www.co2captureproject.org