MiReCOL: Developing corrective measures for CO_2 storage

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MiReCOL Mitigation and Remediation of CO_2 Leakage

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TNO innovation for life

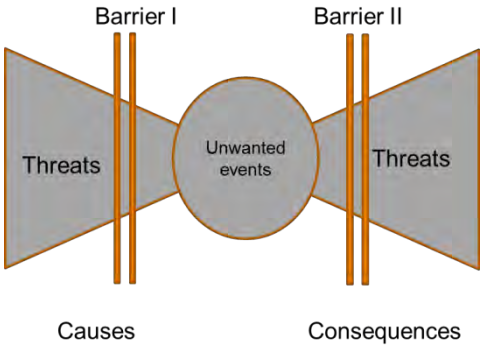
The MiReCOL Project

Integrated demo-scale projects are currently being developed to demonstrate the feasibility of CCS. As part of the license application, these projects must develop a corrective measures plan, which describes the measures that can be taken when the CO_2 in the subsurface behaves in an unexpected way.
The MiReCOL project supports the development of corrective measures plans and helps building confidence in the safety of deep subsurface CO_2 storage.

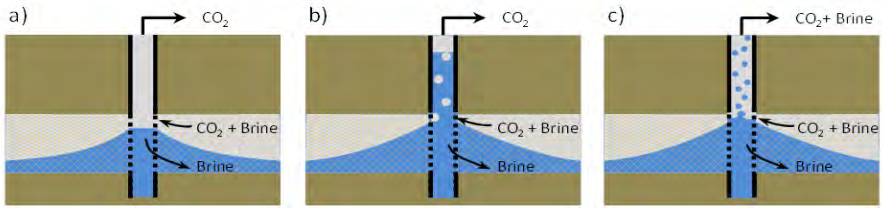
Setup of the MiReCOL project

The results from the MiReCOL project become relevant if, at some point during a CCS project, a 'significant irregularity' occurs. While a 'significant irregularity' may signal a threat to the safety and security of storage, the decision to take action should depend on both the **unmitigated risk** and the **mitigated risk**. The former represents the risk associated with the undesired behaviour of CO_2 that is detected in the subsurface, before any corrective actions are taken. The latter is the risk associated with the storage complex after applying the corrective or mitigation measure
Three general scenarios are considered in the MiReCOL project, all related to processes in the (deep) subsurface:

1. Lack of conformance in the storage reservoir
2. Natural barrier breach (faults, caprock)
3. Well barrier loss



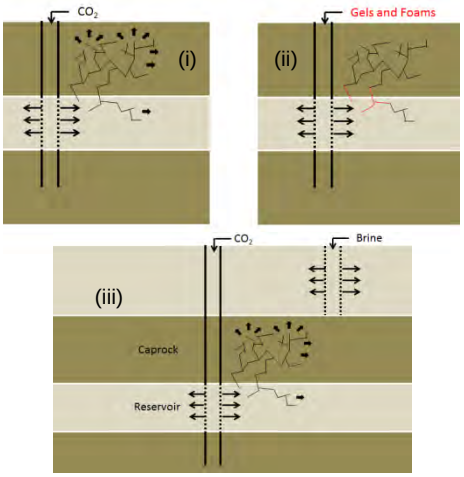
Bow-tie representation of threats (left side), events (centre) and consequences or calamities (right-hand side). Barrier II, on the right hand side, represents mitigation and remediation measures, the subject of MiReCOL.



Schematic of three operational modes during a CO_2 back production test: (a) small production rates produce pure CO_2 at wellhead elevation; (b) increasing production rates evoke a rising water column with CO_2 bubbles inside; (c) production rates beyond a specific level cause dispersed brine entrained by CO_2 at wellhead elevation.

Storage reservoir

One of the areas in a storage complex where corrective measures can be applied is the storage reservoir, in cases when unexpected fluid flow represents a threat to safe and secure storage. An example would be a case in which the CO_2 plume is migrating towards a spill point or a fault zone. Effective corrective measure could be CO_2 back-production or brine withdrawal.

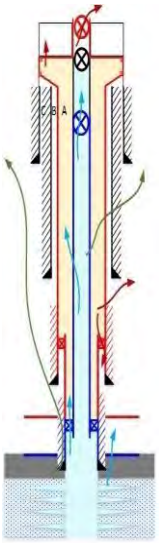


Examples of corrective measures: (i) Stress reduction by pressure management (ii) Gels and Foam to close fractures (iii) hydraulic barrier by brine injection

Faults, Fractures and Caprock

Reduction or interruption of undesired migration through faults and fracture networks will be studied from several viewpoints: (i) a self-healing approach in which the effect of the modification of the stress field after back production may result in a lower leakage rate; (ii) an approach in which one tries to stop or decrease locally the gas flow through fractures by using sealants (gels, foams); and (iii) at larger scales create hydraulic or gas barriers to prevent gas migration through the cap rock.

Well barrier loss



Wells are generally considered to represent the highest risk of leakages in a CO_2 storage project. Well leakages are caused by failure of one or several well barrier elements (e.g. tubing, cement).
The MiReCOL project will review the available remediation technologies and evaluate how these can be applied to remediate leakages for a selection of the most likely CO_2 leakage scenarios.

Schematic illustration of some potential leak pathways due to well barrier element failures in an active CO_2 well.

MiReCOL toolbox

The combined description of remediation techniques will feed into guidelines. The guidelines will contain, for each remediation technique considered, an evaluation based on carbon footprint and other environmental impact; timescale to effective cessation of leakage; likelihood of success; economic cost; location of retention of the CO_2 and longevity of remediation.
The guidelines represent the project's main result, which will be published as a web-based toolbox.

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