

MiReCOL: mitigation and remediation for CO₂ storage

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CO2Geonet Open Forum 2016 2



Mitigation and Remediation of CO₂ Leakage





Currently available techniques

Existing techniques

- Pressure management = suspend injection
- \rightarrow Back production of CO₂
- Well remediation techniques







MiReCOL objective

To develop a toolbox of techniques to mitigate / remediate undesired migration or leakage of CO₂

Support the definition of corrective measures plans

→Help building confidence in deep subsurface storage of CO₂





Mitigation / remediation techniques considered

Reservoir

- Pressure control, flow diversion
- Back production
- CO₂ immobilisation (gels, foams)
- Nitrogen injection
- Nanoparticles

> Faults

- `Managing' faults
 - Immobilising flow: gels, foams
 - Creating fracture networks

>Wells

Injection of sealants

innovation

- Injection of reactive suspension
- Smart cement

- > Field tests
 - Back production
 - > Ketzin 2014
 - > K-12b 2014
 - Bečej: injection of reactive materials

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Example: back production



Gas back production data at K12-B. Data used to assess feasibility of back-producing injected CO_2 as corrective measure

Installations at Ketzin (Germany) For back-production test. Data to be used to asses feasibility Of back producing stored CO₂.



Picture courtesy T. Kollersberger, GFZ

innovation for life



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Example: foam injection





Surfactant injection into fault





Project approach

Central concept is risk level

- Merit of mitigation or remediation technique is obtained by establishing overall risk level *before* and *after* deployment of the technique
 - Unmitigated risk (i.e., threat or leak has occurred, but no action is taken)
 - Mitigated risk (i.e., residual risk of threat or leak after deployment of mitigation or remediation technique, plus the impact of the deployment of the technique on the risk level of the storage site)
- A mitigating or remediating action should be taken only when the mitigated risk is lower than the unmitigated risk





Project approach

Site specificity vs general guidelines

- In reality, the details of threats to safe and secure storage, and of leakage events are strongly **site specific**, and so are the options to mitigate or remediate
- The project will study mitigation and remediation techniques on a range of real or realistic storage complexes, to derive a range of site-specific results, from which more general conclusions will be drawn









Results of the project: Corrective measures handbook

"Handbook" of

remediation and mitigation options that can be applied in the deep subsurface.

- Handbook to inform operators, regulators, public
- Results in handbook based on MiReCOL modelling on a variety of scenarios, to illustrate value of remediation & mitigation options

MiReCOL Mitigation as Remediation W ₂ Leakage	et About 🖍 Input 📓 Handbook		
🔳 Ha	Indbook		
Polymer resin for squeezing Flow diversion to nearby	Polymer-gel remediation		
compartment	Overview		
Gel and foam injection as flow diversion	This study focuses on solutions to mitigate CO2 migration through naturally occurring faults, using a polymer-gel to drastically reduce the permeability of the fault.		
Brine/water injection as flow	Method		
diversion Immobilization of CO2 in solid reaction products Impact of hysteresis on	Our idea is to create and use hydro-fractures to transport the sealant gel to the leaky fault to mitigate or remediate the CO2 leakage.We want to reach a leaking fault (or fracture) in the reservoir and spread as more sealant as we can on a surface as wide as possible. Faults and fractures are surrounded by a damaged zone with permeability much higher than the reservoir (up to 10 times higher) and we can use thi higher permeability to spread the sealant polymer on a wider surface.		
CO2 recovery	Materials and Costs		
CO2 back-production	Low viscosity polymers.		
Brine/water withdrawal as	Associated Risks and Impacts		
pressure management and flow diversion Modifying the stress field to decrease leakage rate	ement and Current results shows that it may be technically feasible (with proper choices of polymer-gel and to mitigate CO2 leakage through a leaking fault. However, it should be emphasized that only techn feasibility is considered in the current study; the cost associated with this mitigation method could be a statement of the statement of the statement study.		
Diversion of CO2 to nearby	Application Areas		
reservoir	In the WP6 we are not interested in migration of CO2 through leaking wells, but in other problematic case for example through caprock failings or leaking faults and fractures or high permeability areas. The most common solution adopted in these situations is perhaps to relief the pressure in the CO2 storage formatit Decreasing the pressure in the formation by dissolving CO2 or stopping the injection of CO2, can be a		
Polymer-gel remediation			
Foam generation	successful technique to reduce the leakage or the avoid that the CO2 reaches potentially dangerous area, like faults or highly permeable layers. In some cases this system might not be enough to prevent leakage,		
Hydraulic barrier	and other approaches, such as drilling new injection wells have to be contemplate.		
CO2 reactive suspensions	Case Studios		

Example of web-based Handbook

Results of the project: Corrective measures Tool

- Web-based tool: suggests suitability of remediation and mitigation options for a specific site and a specific leakage scenario
 - Tool informs operators, regulators
 - Provides first-order assessment of options available to operator to remediate or mitigate undesired migration in or leakage from storage complex



Example of input & output from web-based MiReCOL corrective measures tool

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Results of the project

- Project started March 2015, now starting final year
 - Formulate guidelines for mitigation / remediation measures
 - Construct tool, write Handbook

Gassnova – CO2Geonet workshop, Wednesday

- → Two technical papers
- Detailed presentation of Tool – discussion!

Similarity

The similarity plot displays the similarity between the operator's input and the closest scientific input for that mitigation technique. This is not a display of the appropriateness of the mitigation technique.



"These data are based on the Gower similarity coefficient and has been adjusted to a 100-point scale (Gower, J.C., 1971. A general coefficient of similarity and some of its properties. *Biometrics*, pp.857-871.).

el and foam injection as flow diversion		
Output	Estimated Value	
Likelihood of success	70 %	
Spatial extent	2 km	
Cost	€ 100000	
Response time	2 months	
Longevity of remediation	Infinite	
rine/water injection as flow diversion		
nmobilization of CO2 in solid reaction products		
sible		
low diversion to nearby compartment		

Example of output from web-based MiReCOL corrective measures tool

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