**IEAGHG Information Paper 2016-IP52; MiReCOL (Mitigation and Remediation of $CO_2$ Leakage) Close-Out Meeting**

MiReCOL is an EU funded project with the objective of investigating the effectiveness of remediation and mitigation techniques in the event of leakage from a $CO_2$ storage site. This collaborative endeavour includes 11 different European partners from academia and industry. The key results from the project, which covered migration management, leakage through faults of caprock and leakage along wells, were discussed at the final project meeting in Brussels on 7th December 2016. The meeting also included an overview of a remediation programme following a $CO_2$ blow-out at the Bečej gas field in Serbia.

One of the main forms of mitigation is the concept of migration management especially in instances where unexpected fluid flow might occur. The MiReCOL project included an example based on the Johansen field in the Norwegian sector of the North Sea. There is a reservoir at 1,600 – 2,400 with a good seal. Modelling was used to simulate the use of foam to block $CO_2$ spillage from a reservoir spill point. The model was able to demonstrated reduced fluid mobility by blocking the spill point.

In another case, based on the Ketzin pilot project, the effectiveness of back production was assessed and simulated as a means of achieving a reduction in reservoir pressure. Geoelectric monitoring at the production well was capable of tracking the back-production process. Numerical simulations conducted in advance of the field test underestimated the quantity of back-produced $CO_2$ by ~14%. Better results were achieved with hysteresis but more research is required to fully understand the processes involved.

Leakage through faults and fractures following $CO_2$ injection is a potential risk at storage sites. Fluid transport properties of faults applied in Bečej field in Serbia, and P18/P15 offshore Rotterdam, have been modelled as part of the MiReCOL project. $CO_2$ injection decreases stress on faults and could cause slip. A model of fault leakage in the Bečej field showed a relatively small effect on stress and fault permeability but the simulation was only run for 5 years. Fault sealants using polymer gel injected above the storage formation and in the reservoir showed a reduction in $CO_2$ migration.

A key remediation measure used in the oil and gas industry and applicable to $CO_2$ storage is the use of cement and reactive polymers to plug leaks and control fluid migration in reservoirs. MiReCOL has reviewed the effectiveness of these materials in $CO_2$ reservoirs. Cement squeeze and pressure-activated polymers have been tested. In one example, laboratory experiments designed to simulate North Sea conditions (92 C, 350 bar) showed that a reduction in cement permeability is possible. One of the MiReCOL partners has demonstrated that $CO_2$ permeability can be reduced by more than 99% in high permeability sandstones by using a polymer gel.

One of the best examples of remediation covered by MiReCOL was the successful control of a persistent gas leak. In 1968 there was a major blow-out which lasted 8 months at Bečej gas field in northern Serbia. The lower section of the well collapsed causing uncontrolled migration of gas into the overburden until 2007. At this stage a relief well was drilled. Sealant material was injected and tested at this site. A new simple formulation was used of a reactive K-silicate compound that reacts with acetic acid. A gel formed after 8.5 hrs. Although only $2m^3$ was injected and not the $8m^3$ that was planned the technique proved to be effective. Some important lessons have been drawn from this field trial. The use of reactive materials can be compromised by contamination with drilling mud. Shrinkage effects and of down-hole temperatures need to be taken into account. The operational strategy also needs to be achieved with incremental steps over shorten injection time intervals to be

effective. Prolonged injection can causing mixing with formation water creating less effective blockages.

MiReCOL has generated a wealth of useful information and examples which will aid the secure development of $CO_2$ storage sites. Operators will now have more material to help plan for mitigation and remediation. An online tool is currently under development which will be able to provide different options for conditions selected by online users. A full compendium of technical reports from the project will also be published.

For more information please go to the MiReCOL website http://www.mirecol-co2.eu/

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