ULTimateCO2 project: Field experiment in an underground rock laboratory to study the well sealing integrity in the context of CO2 geological storage

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Abstract

Wells drilled through low-permeable caprock are potential connections between the CO_2 storage reservoir and overlying sensitive targets like aquifers and targets located at the surface. The long term well sealing integrity is therefore essential for the fluids confinements.

The well sealing integrity can be lowered by geochemical reactions occurring between well compartments (cement, caprock, casing) and fluids (CO_2-saturated water as well as CO_2 and impurities contained in the gas stream), possibly leading to the degradation of transport properties of cement and caprock, and to the creation of escaping pathways through the casing. Cement reactivity is of first concern and a significant amount of studies have been already carried out to characterize these interactions. Despite this large effort of the scientific community, large uncertainties still exist about the range of porosity and permeability variations expected for cement degraded by chemical interactions driven by the injected gas mixtures (CO_2 and eventual impurities) , as well as about the long-term evolution of these transport properties.

The integrity can also be decreased due to *in situ* operations. During the drilling, the caprock can be damaged leading to the formation of an excavation damaged zone; the quality and placement of the cement during the completion is also essential for a suitable bounding. All these steps may lead to the creation of annular pathways within the compartments and at the interfaces (i.e. caprock – cement sheet; cement sheet – casing; casing – cement plug). The migration of fluids through these paths may lead to geochemical processes possibly enhancing the lack of sealing integrity. Some field studies have assessed the consequences of the contact between wellbores and CO_2 in an EOR fields and at a natural CO_2 reservoir. They highlighted in particular the lack of integrity that may occur at the interfaces rather than through the cement matrix. Understanding the near well sealing integrity then requires studying the potential pathways and associated migration via altered well compartments but also along interfaces with deficient bounding: it implies the study of the well environment as a whole.

So far, the issue of well environment integrity was investigated using synthetic interfaces and simulating the flow of CO_2 and brine in laboratory. The main issue raised by these experiments concerns the representativeness of artificially made interfaces with regards to interfaces encountered in situ.

To go beyond these limits, we propose to develop an integrated framework constituted by field experiment, laboratory characterization and modeling in order to get better insights into the conditions of a good well sealing integrity on the long term scale. Our work is carried out within the context of the EU-FP7 project UltimateCO2 (Understanding the Long Term fate of geologically stored CO2) led by BRGM and dedicated to the long term fate of CO_2 focusing on several physical processes. A field experiment is thus being currently set-up in the underground rock laboratory of Mont-Terri (St Ursanne, canton of Jura, Switzerland). The purpose is to rebuild well features (including casing and cement sheet) at scale 1:1. The experimental setup consists of a wellbore

drilled within the Opalinus Clay of the Mont-Terri URL, which is a well-documented caprock like formation. The drilling and well completion in the field will be done according to the actual standards in the aim of reconstructing interfaces between the caprock, the cement and the casing steel that would be close to the ones observed *in situ*. These well features will then be dipped within a CO_2 stream; the experiment will be monitored, following key parameters at different levels (pressure, temperature) as well as sampling fluids at regular intervals. The experiment is planned to last two years. An artificial defect will be added in order to follow one leakage and its evolution across time. At the end of the contact, the well (and clay vicinity) will be over-cored in order to carry out several characterizations in lab: petro-physical and mineralogical characterizations will thus allow pointing out evidences of leakages and degradations.

In parallel with the experimental work, a modeling effort is performed focused on both geochemical and transport aspects of the interactions between fluids and well compartments. The calibration of numerical model against experimental results will be performed all along the duration of the experiment. The long-term integrity of well environment will be then tentatively tackled by means of adapted modeling and extrapolating tools, including uncertainties assessment and propagation.