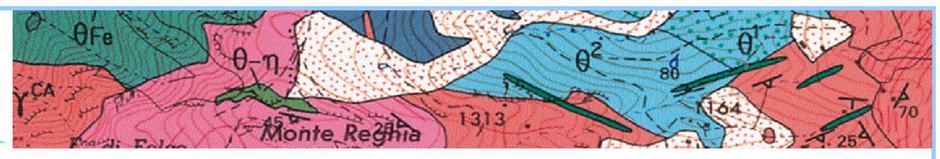


Field experiment in an underground rock laboratory to study the well integrity in the context of CO_2 geological storage

Context and purposes

> **Wells (decommissioned or active)** 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

> **Caprock-cement-casing (extra-casing)** and **casing-cement (intra-casing)** systems are considered as **barriers** against potential migration outside the reservoir

> Wellbore integrity may be compromised in several ways:

(i) **Operational defects** due to *in situ* operations (caprock damaging during drilling, poor cement mixing or placement, well environment damaging during the life of well due to stress conditions changes, internal isolation defects during the abandonment stage);

(ii) **Chemical degradation** (cement reactivity in wet CO_2 or CO_2-rich brine conditions, casing corrosion).

> Potential pathways location in the wellbore environment:

1 - Migration through damaged zone in the caprock;
2 - Migration through the caprock/cement interface;
3 - Migration through degraded or fractured cement (sheet or plug);
4 - Migration through the cement (sheet or plug)/casing interface.

> The multiple potential pathways require the study of the **whole well-system**.

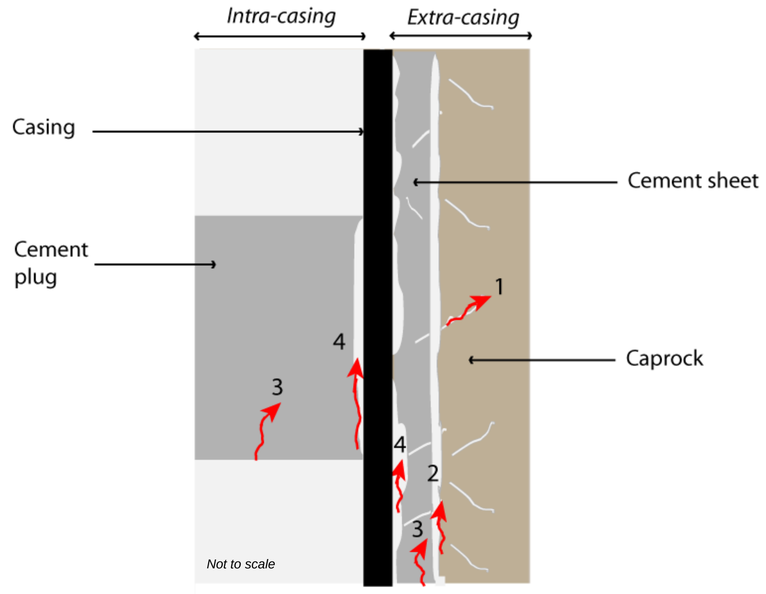
The **complex geochemistry** in the well-environment and its influence on the migration across the pathways needs to be assessed in the meantime to have a full picture of the problem.

> Purposes:

(i) Evaluating the **effective (intra and extra-casing) hydraulic and transport properties** of the well environment;

(ii) Evaluating the **interactions between CO_2 (and formation fluid) and the well environment** (close formation, cement, casing);

(iii) Assessing the **consequences of the interactions on the effective hydraulic and transport properties** of the well environment.



Underground Rock Laboratory experiment

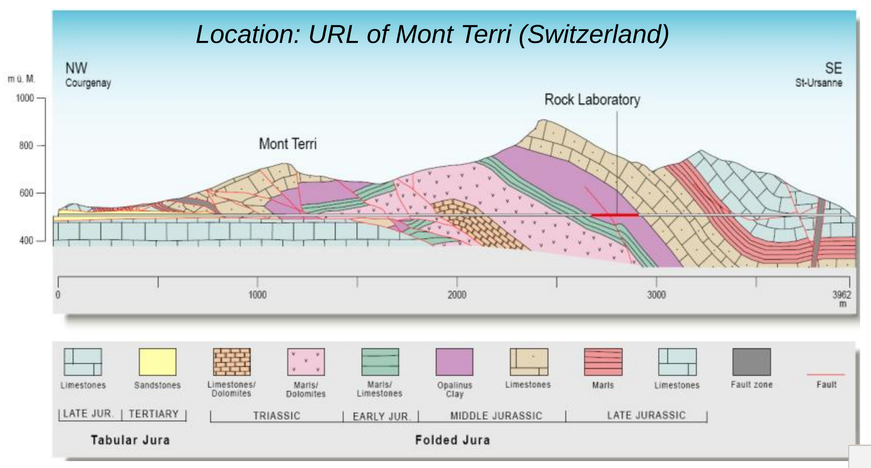
> **Building of well features** and instrumentation to **monitor flow intra and extra-casing**

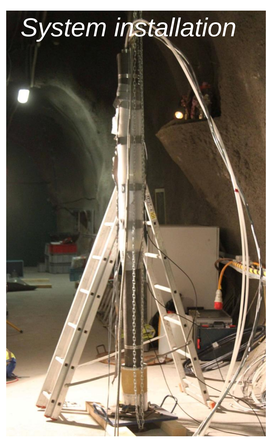
Different stages:

(i) **Initial hydraulic characterization** of the system and inert gas transport test (2012-2013);

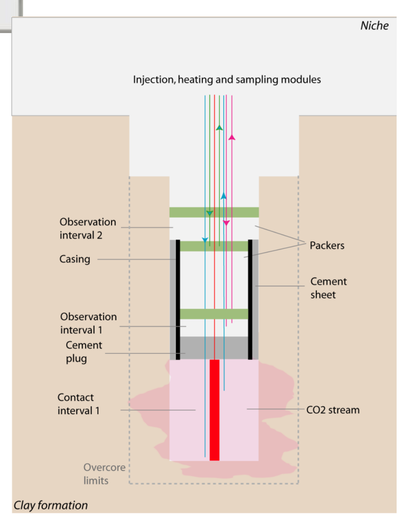
(ii) **Contact with CO_2** during more than one year with constant monitoring and regular fluid sampling (2013-2014);

(iii) **Overcoring of the system** for lab characterization (2014).





Conceptual layout



Laboratory experiments

> **Reactivity** of caprock and cement:

(i) **Initial petrophysical, mineralogical and geochemical characterization** of cap rock and cement as well as initial chemical characterization of brine to be used for the experiment on site;

(ii) Experimental **assessment of CO_2-rich brine/cap rock/cement interactions** by exposing cap rock/cement to CO_2-rich brine at on site conditions (temperature, pressure) with experimental setup (autoclave);

(iii) Evaluation of reactions/reaction kinetics encountered in (ii) and their **impact on cap rock and cement integrity** by using petrophysical, mineralogical and geochemical characterization of cap rock/cement as well as chemical characterization of brine after experiment.

> **Multi-scale overcore caracterization**

(XRay diffraction, SEM coupled to raman, CEC evolution, leaching experiment):

(i) Identification of mineralogical changes

(ii) Observation of microstructural changes

(iii) Quantification of the scale of diffusion processes at the interface

Modelling

> **Multiphase flow and transport modelling**

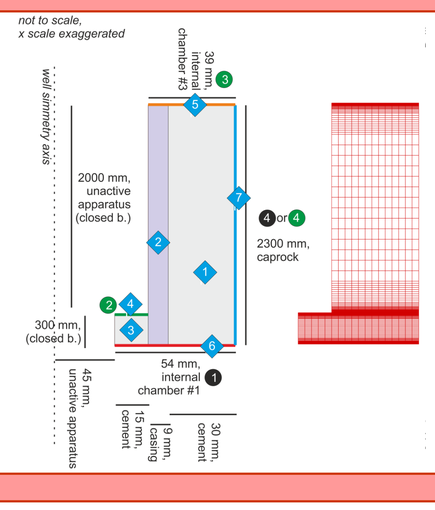
focused on the **prediction of fluids migration** along the different compartments of the experimental apparatus (effective hydraulic and transport properties)

specific investigation of the **role of discontinuities and interfaces** as possible preferential leakage paths

> **Geochemical and reactive transport modelling**

focused on the **prediction of mineralogical alterations** induced by the interaction between the different media and gaseous CO_2 and/or CO_2-charged aqueous solutions.

specific investigation of the role of discontinuities and interfaces as preferential leakage paths and **feedback** of mineral precipitation/dissolution reactions on **hydraulic properties** of the media



> **Several steps**

(i) Definition of the initial state

(ii) Predictive modelling

(iii) Calibration of the numerical models

(iv) Long-term extrapolation

JC. Manceau[1], P. Audigane[1], F. Claret[1], M.Parmentier[1], T.J. Tambach[2], F. Gherardi[3], A. Dimier[4], O. Ukelis[4], E. Jeandel[4], F. Cladt[4], R. Zorn[4], T. Yalamas[5], C. Nussbaum[6], A. Laurent[7], T. Fierz[7], M. Piedevache[7] / contact: jc.manceau@brgm.fr

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