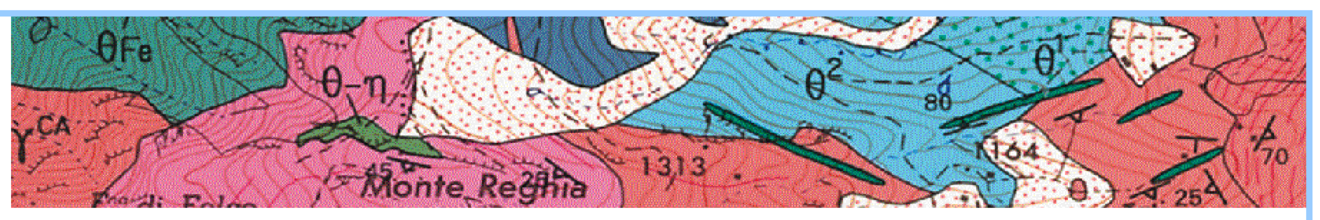

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ULTimateCO$_2$: Understanding the Long-Term fate of geologically stored CO$_2$

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Introduction

Although the technical feasibility of CO$_2$ Capture & Storage (CCS) has been proven with the development of small-scale pilot sites, the EU Directive on the Geological Storage of CO$_2$ requires operators to demonstrate that the long-term fate of the CO$_2$ in the reservoir will ensure permanent containment. But many questions prevail concerning the behaviour and impact of the injected CO$_2$: "***What will happen to the CO$_2$?*** "***Will it leak from the reservoir?***" "***Will it stay underground?***" "***And for how long?***". Such questions can only be answered convincingly through a better understanding of a chain of complex physical and chemical processes.

ULTimateCO$_2$, a four-year FP7 collaborative project coordinated by BRGM, unites 12 partners (research institutes, universities, industrialists) and a varied panel of experts (NGOs, national authority representatives, IEAGHG, …) in the aim of shedding light on the long-term processes associated with the geological storage of CO$_2$.

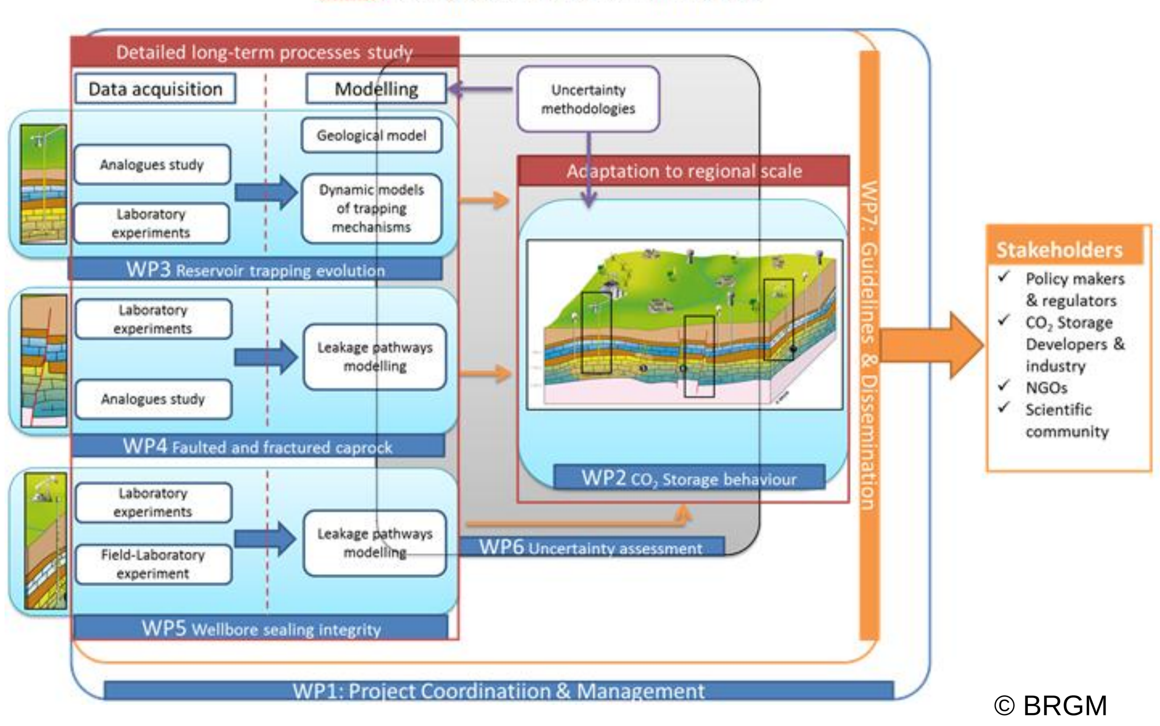
Objectives

The aim of **ULTimateCO$_2$** is to significantly advance our knowledge of specific processes that may affect the long-term fate of geologically stored CO$_2$ and yield improved and validated tools for predicting long-term storage site performance through a dedicated programme covering:

i) Detailed laboratory, field and modelling studies of the most relevant physical and chemical processes involved in CO$_2$ storage and their impacts in the long-term;

ii) Integration of the results so as to assess the overall long-term behaviour of storage sites at reservoir and basin scales in terms of efficiency and security, and including other important aspects, such as far-field brine displacement and fluid mixing, integrity of sealed faults compartmentalizing depleted gas reservoirs, and chemical changes in overlying groundwater resources in the case of leakage through abandoned wells.

Work package structure of ULTimateCO$_2$



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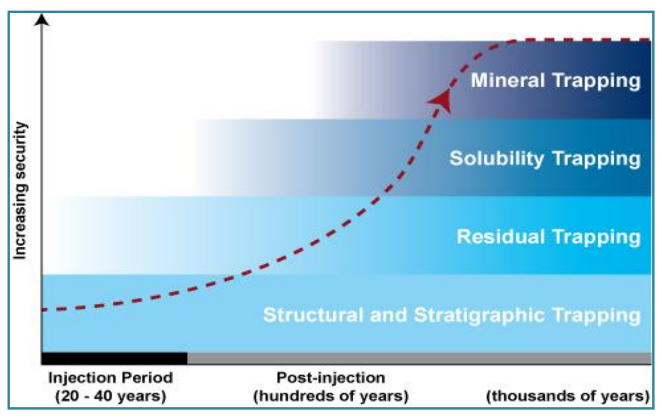
What we do and why

To be in a position to ensure safe and efficient geological storage of CO$_2$ in the long term, we need to focus on any potential failure scenarios.
Detailed research is being carried out on 3 crucial elements of a storage site:

Reservoir (WP3)

How: Study all processes of multiphase flow and associated geochemical reactivity through laboratory experiments and numerical modelling in order to assess how CO$_2$ trapping mechanisms (Structural, Residual, Dissolution, Mineral) evolve with time. The results are made more pertinent by comparison with field data of natural analogues.

Why: i) improve demonstration of the safety of reservoir trapping; ii) provide static models for evaluation of SRDM trapping at reservoir scales; iii) assess specific chemical processes in storage formations over long time scales.



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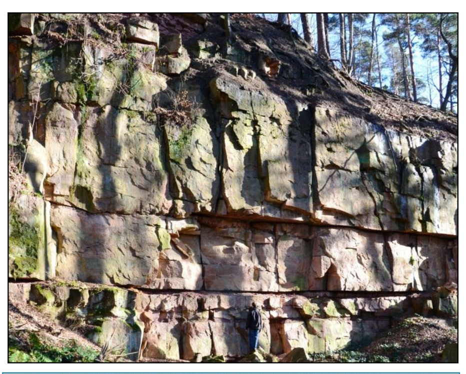

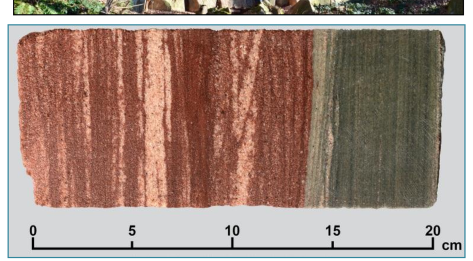

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Caprock (WP4)

How: Detailed study of a faulted or fractured shaly caprock based on i) field data: existing data on gas reservoirs in the North Sea that have shown leakage, plus fractured reservoir analogues ii) laboratory tests on shale cores altered by geochemical acidification, and iii) numerical modelling coupling geochemical alteration of shale and behaviour mechanics.

Why: To assess the long-term integrity of sealed faults or fractured caprocks – based on fault and fracture network properties from field data and incorporating the effects of chemical degradation – by investigating the influence of long-term changes in thermo-mechanical conditions (stress, fluid pressure and temperature conditions) and of the pressure history in case of storage in depleted gas reservoirs

Wellbore (WP5)

How: by undertaking an innovative experiment in the Underground Rock Laboratory (URL) of Mont Terri in Switzerland to understand the processes affecting well integrity. A small section of a wellbore is reproduced in the Opalinus Clay of the URL (caprock-like formation) at scale 1:1. The evolution of this system integrity is recorded before and after introduction of CO$_2$, and for different temperature conditions through pressure-tests, and fluid sampling and analysis. Modeling and lab experiments, including material characterization, are performed in parallel to enable a better interpretation and understanding of the observations.

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Why: To evaluate the well sealing integrity by a better understanding of:

- the bounding quality between the well compartments;
- fluid-rock interactions occurring within the different well compartments (casing, cement, caprock);
- the influence of CO$_2$ and other parameters on the sealing properties of the well

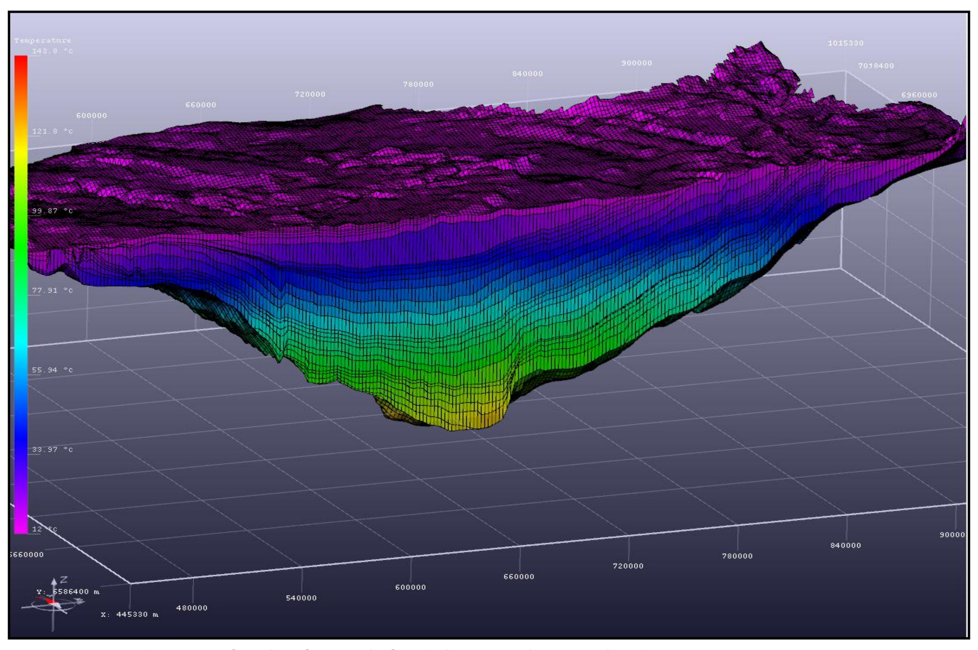
Use of the Mont Terri URL also offers access through galleries to representative samples of caprock clay in order to perform unique experiments on well-leakage assessment

But we can only gain the full picture if these smaller-scale, localized features are merged and upscaled to the context of the whole storage site.

Integration of the results and adaptation to regional scale (WP2)

The results of the detailed studies at reservoir, caprock and wellbore scale are then transposed to sedimentary basin scale in order to consider the long-term effects within the whole storage site and beyond:

- impact studies on basin hydrogeology & brine displacement with construction of a 3D model of the Paris Basin and the Southern part of the North Sea Bunter Sandstone Formation
- upscaling from local to large scale of trapping mechanisms of CO$_2$ stored in saline aquifers
- long-term sealing integrity of fractured caprock and faulted systems
- impact of CO$_2$ leakage through wells from saline aquifers to overlying groundwaters

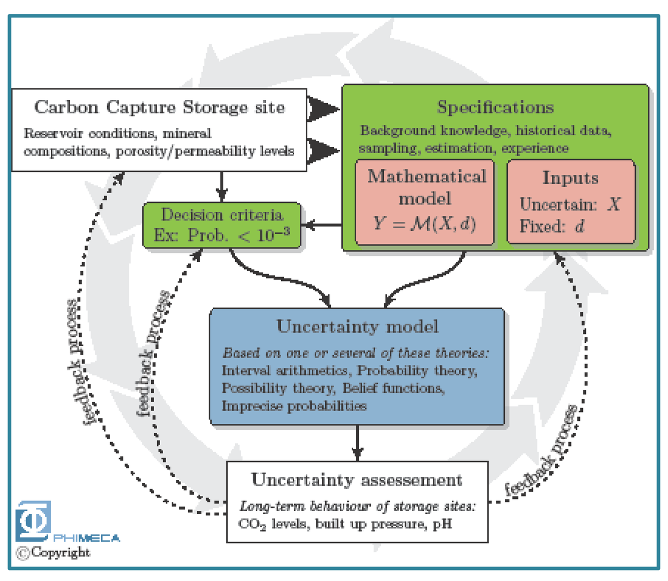


3D geological model of the Paris Basin © IFPEN

But how reliable are the results and can we have confidence in the findings?

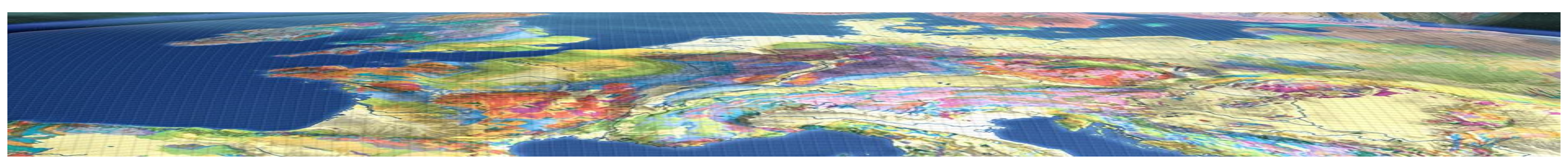
Uncertainty assessment (WP6)

The study of such highly complex processes on time scales stretching to several thousands of years must be accompanied by an assessment of the associated uncertainties. A general methodology applicable to the geophysical systems involved in CO$_2$ storage has been developed and now is being applied to the modelling predictions from WPs 2-5 using different sensitivity and uncertainty approaches (Epistemic or Bayesian). This will increase insight into the spectrum of the possible outcomes from the modelling, and thereby illustrate the unavoidable uncertainty related to our scenario-based predictions



Guidelines and dissemination (WP7)

The overall aim of ULTimateCO$_2$ is to increase understanding on the efficiency, safety, and uncertainties of the long-term evolution of CO$_2$ geological storage. The scientific findings will be disseminated using appropriate tools to four target groups: policy makers & regulators, CO$_2$ storage developers & industry, the scientific community and NGOs. Integration of the research results of WPs 2-6 will enable identification of broader generic lessons learned that will be compiled into a set of guidelines on the long-term performance of a storage site, particularly aimed at operators and legislators.



More information on www.ultimateco2.eu

www.brgm.fr