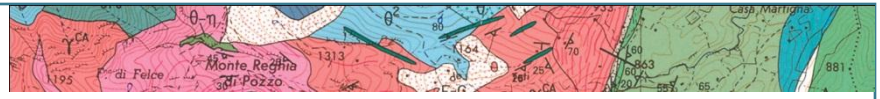


ULTimateCO2

"Understanding the Long Term fate of geologically stored CO_2"

FP7 European Project
Call *FP7-ENERGY-2011-1* AREA ENERGY.5.2: CO2 STORAGE

ULTimate CO_2

SEVENTH FRAMEWORK PROGRAMME

Géosciences pour une Terre durable
brgm

Concept

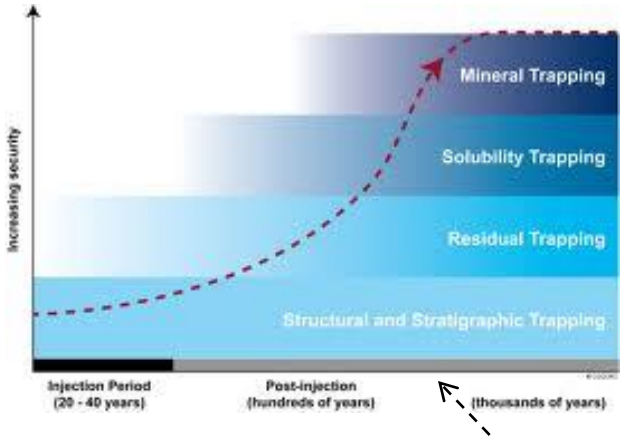
- Although the technical feasibility of CCS has been proven the EC Directive on the Geological Storage of CO2 requires operators to demonstrate that the long-term fate of the CO2 in the reservoir will ensure **permanent containment**

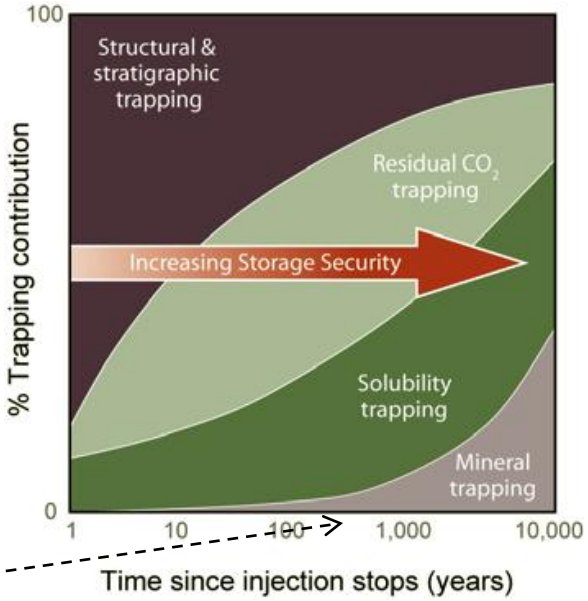
- The general public and their representatives seek answers to questions:
  - “What will happen to the CO2?”
  - “Will it leak from the chosen reservoir?”
  - “Will it stay underground?”
  - “For how long?”

- Not yet have sufficient experience to rely on for this new technology

Long term fate of stored CO2

- The actual vision of the prediction from the IPCC (International Panel of Climate Change) is represented as follows





In ULTimateCO2 Long term is post abandonment period

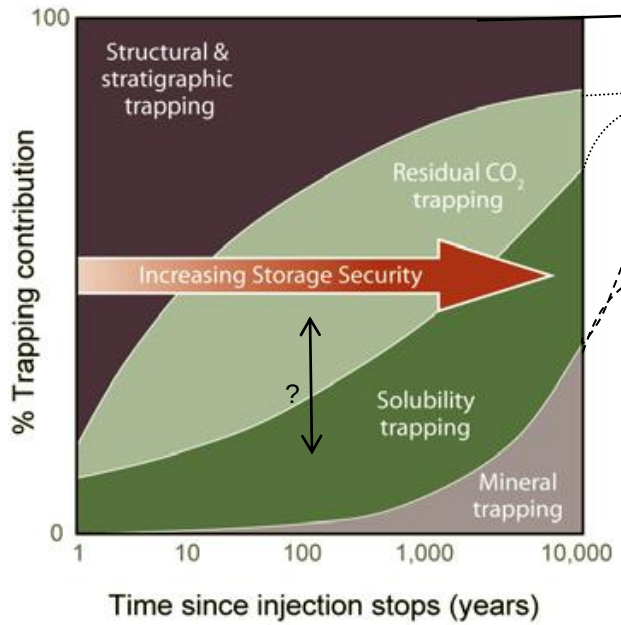
- Identification of trapping mechanisms at specific time scales
- A trend of the importance for each mechanisms is given
- Each of these traps is controlled by complex physical and chemical processes in a complex geological context

Objectives of the project

> Significantly advance our knowledge of specific processes that may affect the understanding of the long-term fate of geologically stored CO2

> Yield validated tools for predicting long-term storage site performance

What if leakage (fault, wells)?



When?

Stabilization?

What is the uncertainty in the predictions?

In a real injection site?

Objectives

- **Laboratory, field and modelling studies of**:
  - trapping mechanisms in the reservoir (structural, dissolution, residual and mineral [SDRM])
  - fluid-rock interactions and effects on mechanical integrity of the caprock
  - leakage associated with mechanical and chemical damage in the well vicinity

- **Integration of the results**
  - into assessing the overall long-term behaviour of storage sites at basin scale in terms of efficiency and security

Objectives

- **Predictions more robust by**
  - addressing the **uncertainty** associated with numerical modelling at all stages

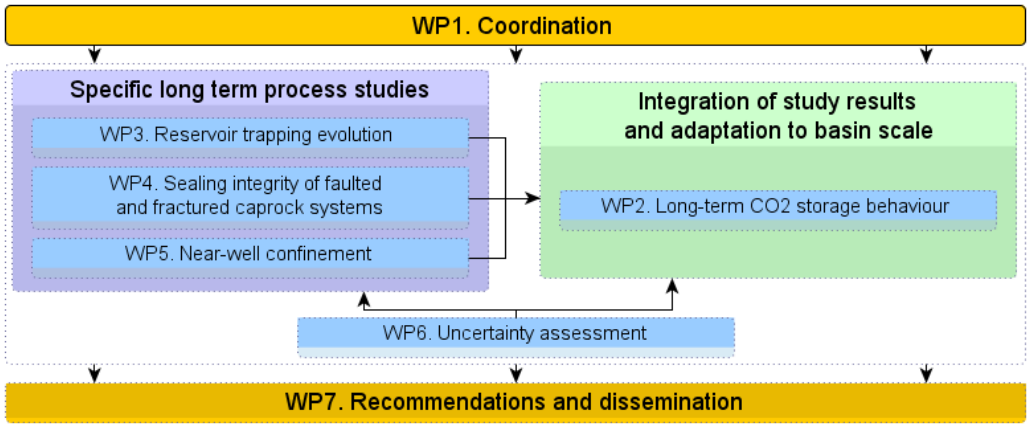
- **Realistic contexts and scales through the close collaboration with at least two demonstration sites**
  - EEPR DonValley (ex-Hatfield) demonstration site in the UK operated by National Grid (offshore sandstone aquifer);
  - NER300 Ouest Lorraine candidate in France operated by ArcelorMittal GeoLorraine (onshore sandstone aquifer);

Objectives

- **Develop guidelines** for operators and regulators to enable a robust demonstration of the assessment of long-term storage site performance:
  - by drawing on the lessons learned within the project,
  - by relevant research internationally
  - through dialogue with targeted stakeholders

- **Help to raise confidence with key stakeholders:**
  - Dissemination of scientific knowledge on the long-term efficiency and safety widely to a broad audience, (Operators of CO2 storage demonstration sites the investors, regulators, policy-makers, the research community and representatives of the general public NGOs and politicians)
  - To improve public perception

Work Plan

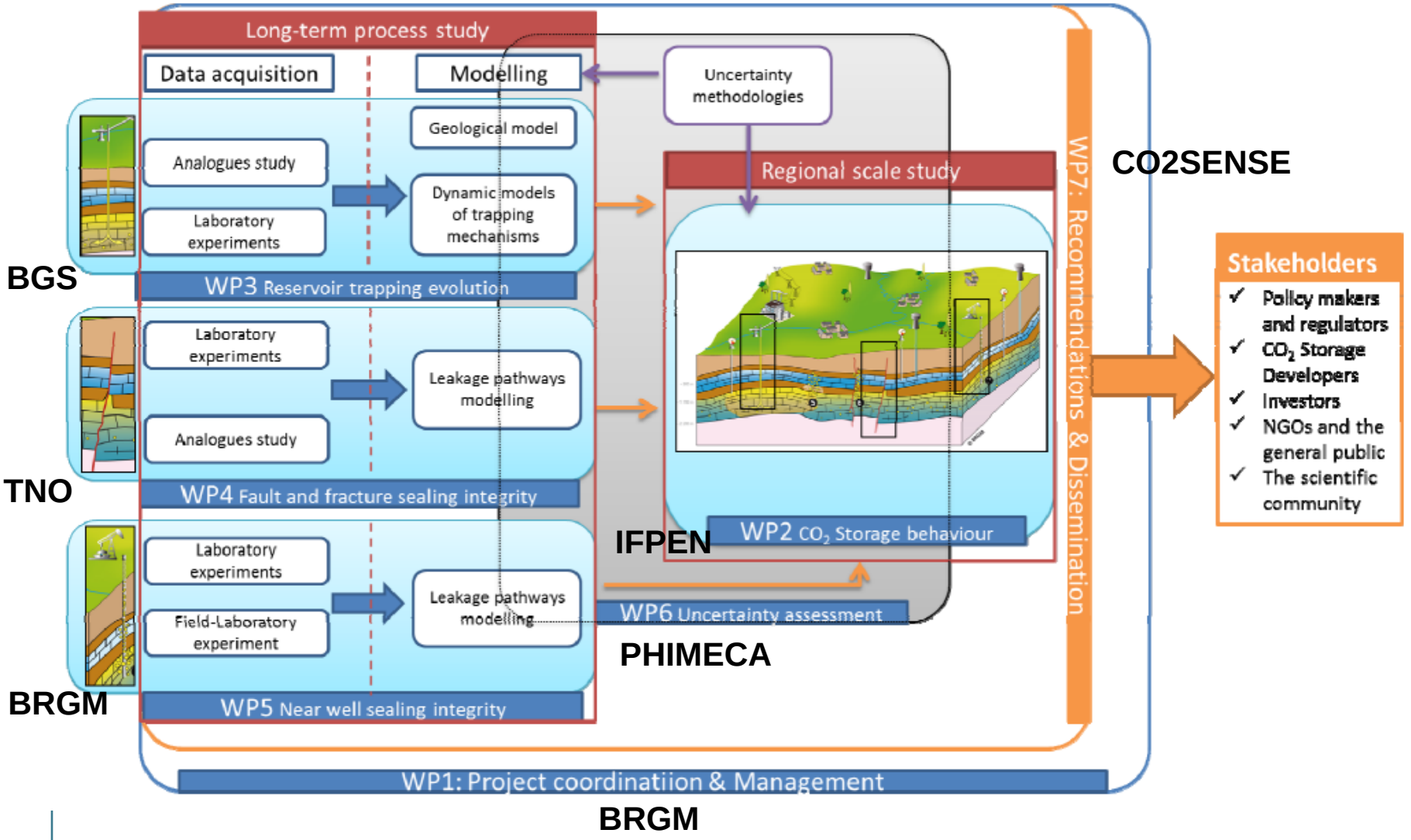


- **WP1** concentrates on project management and coordination
- **WP2** is aimed at integrating and compiling the results of the detailed study of three main aspects (WPs 3, 4 and 5) in order to assess long-term impacts of geological storage at the basin scale. It will also address other important aspects, such as hydro-regional flow, water quality and native fluid displacement. Modelling will integrate field data from CO2 storage demonstration sites to provide test cases
- **WPs 3, 4 and 5** are focused on understanding the three main aspects determining long-term confinement efficiency. Each will integrate numerical modelling, laboratory experiments and geological evidence
- **WP6** is dedicated to uncertainty assessment, and supports all the other work packages by providing them with a framework for addressing the confidence that can be placed on the long-term extrapolation of identified processes, and numerical simulation results
- **WP7** will develop clear guidelines for storage projects enabling site-specific evaluation of the long term fate of geologically stored CO2.

List of participants

CONSORTIUM				ADVISORY BOARD			
R & D Institutes	**Academia**	**Company**	**SME**	**Data Providers**	**CSLF Members**	**Disse-mination stake-holders**	**National regulatory authorities**
• BGR • BGS • BRGM • GEUS • IFPEN • IGG • TNO	• Utrecht University	• GEOGREEN • EIFER	• CO2sense • Phimeca	• National Grid • Arcelor Mittal GeoLorraine • Swissto po	• Alberta Innovates • Lawrence Berkeley National Laboratory • PTRC	• ZERO • IEAGHG	• UK: OCCS (DECC) • France: DGEC (Ministry of Ecology)

ULTimateCO2 Project structure and WP Leaders



WP3 (BGS) – Reservoir Trapping evolution

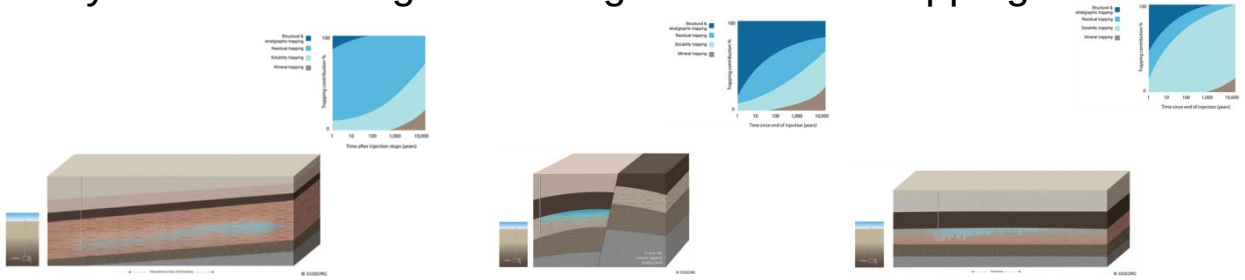
> Objectives:

- To increase the demonstration of the safety of reservoir trapping, leading to an improved evidence-base for permanent containment through better constrained quantitative prediction of long-term CO2 behaviour within the reservoir.
- To demonstrate the range, relative importance and uncertainties of reservoir trapping mechanisms at specific planned large-scale CO2 storage sites at sites selected for future storage,
- To provide static models for evaluation of SDRM trapping at reservoir scales
- To assess specific chemical processes in storage formations over long time scales
- To integrate results and identify broader generic lessons learned for inclusion in WP7

WP3 – Reservoir Trapping evolution

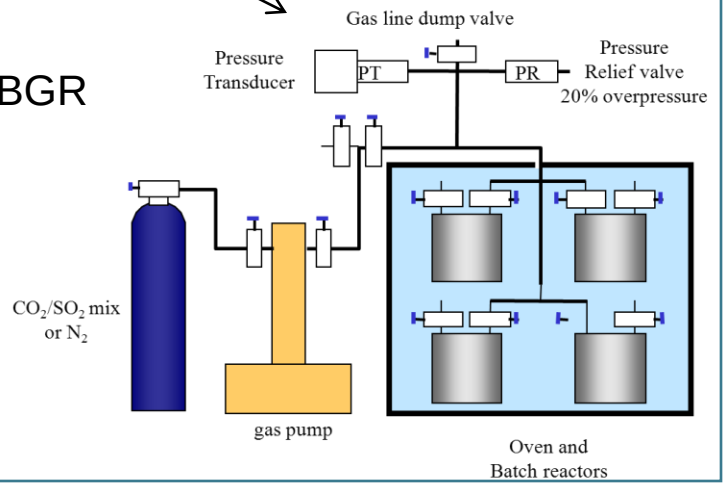
> Tasks:

- Static modelling for structural trapping estimates – Geogreen
- Dynamic modelling of the long-term SDRM trapping mechanisms – IFPEN



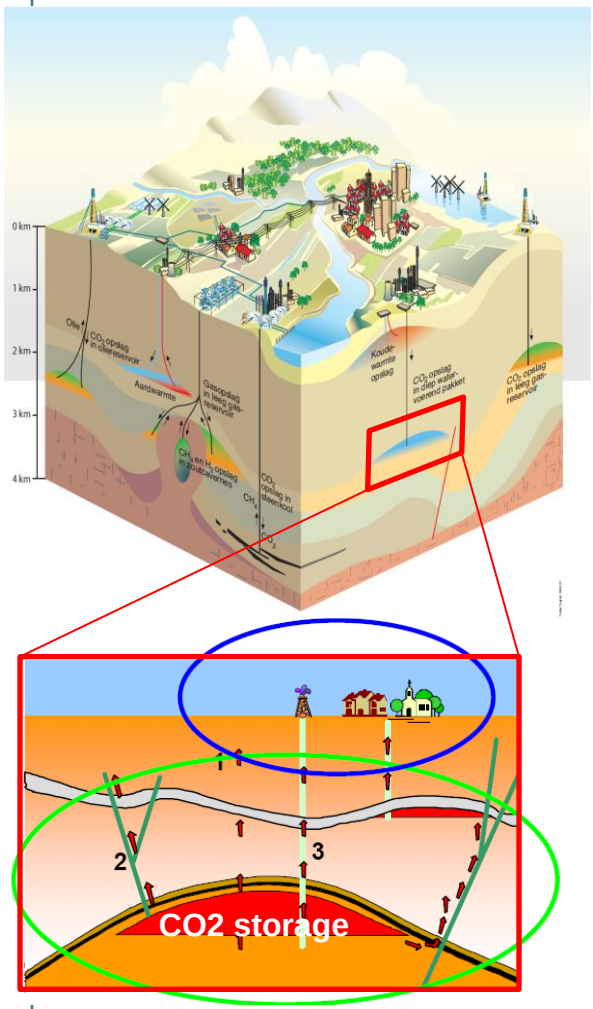
- Evaluation of long-term chemical processes in the storage formation - BGS
  - Well characterised batch experiments
  - constraints on impure CO_2-water-rock reactions.

- Evidence for long-term trapping evolution - BGR



WP4 (TNO) Long-term sealing integrity of faulted and fractured caprock systems-

Setting the scene



Main caprock leakage risks associated with:

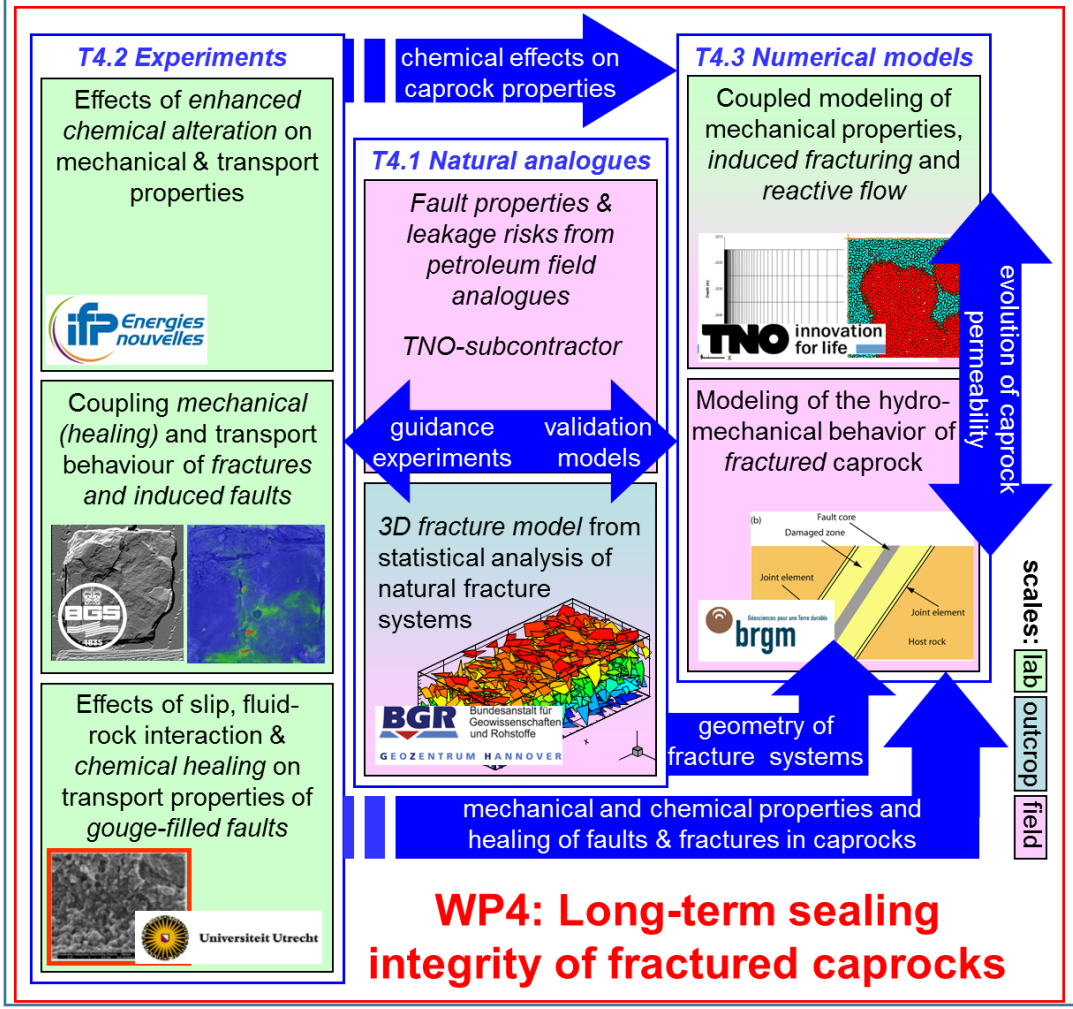
- Pressure changes in reservoir due to CO_2 injection
  → faulted and fractured caprock

- Long term chemical-mechanical fluid-rock interaction of CO_2-rich fluids with reservoir-overburden-faults

  → changes in rock (hydro-mechanical) properties
  → changes in local stress
  → fault reactivation & fracture initiation
  → permeability changes caprock (leakage)

WP4 Long-term sealing integrity of faulted and fractured caprock systems-

An integrated approach



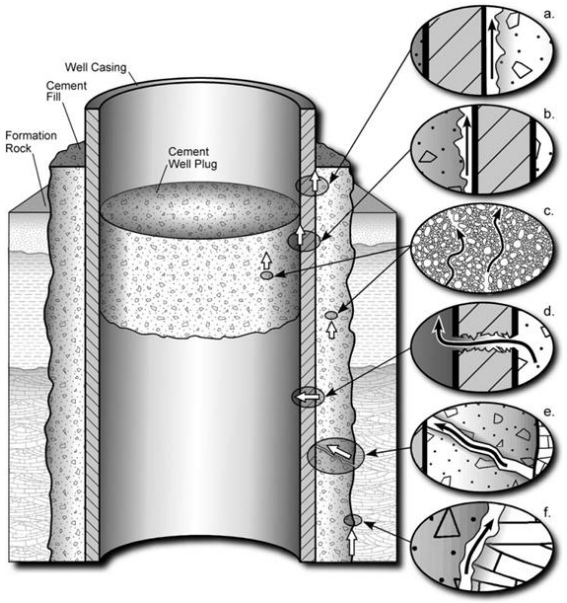
Integration of studies on:

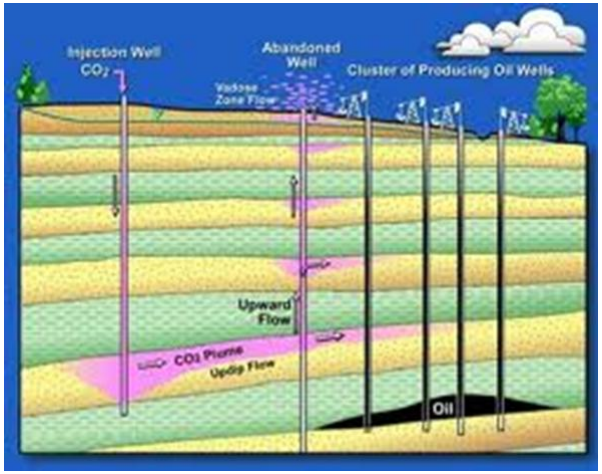
- *natural analogues* (outcrop and petroleum field data, Task 4.1)
- *experiments* on the interaction between CO_2-rich fluids and fractured caprock/fault rock (Task 4.2)
- *models* of hydro-mechanical behaviour and reactive flow of fractured caprock (Task 4.3)

WP5 (BRGM) -Near well sealing integrity

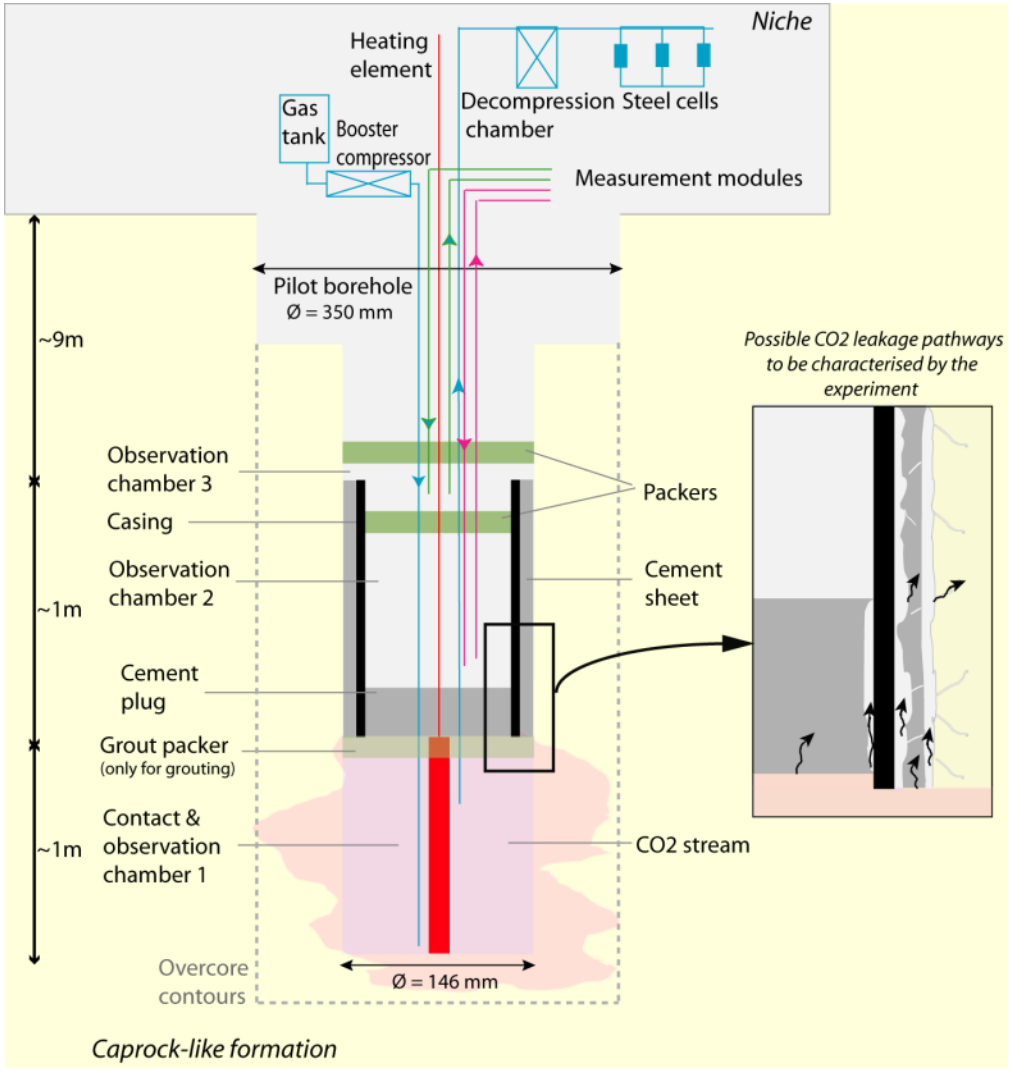
> Objectives:

- determining the interactions between the well compartments (casing, cement sheet, caprock, and cement plug) and the fluid
- observing and evaluating the leaking pathways between the well compartments (interfaces)
- simulating and extrapolating at a long-term scale the sealing properties evolution of the well compartments and their interfaces in contact with CO_2 streams.





1:1 scale Mont Terri Experiment



> Main purposes:

- Leakage pathways
- Reactivity

> Approach:

- Rebuilding well features
- « Dip » these features within CO2 stream
- Overcore at the end

> Conditions:

- P, T to be defined according to the representativity but mainly to site safety
- CO_2 + impurities
- Artificial defects

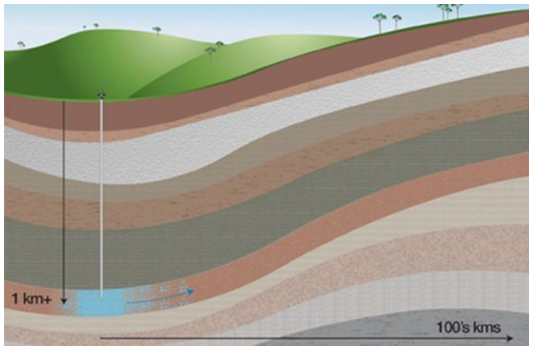
> Possible equipment

- 3 observation chambers
- Regular samplings

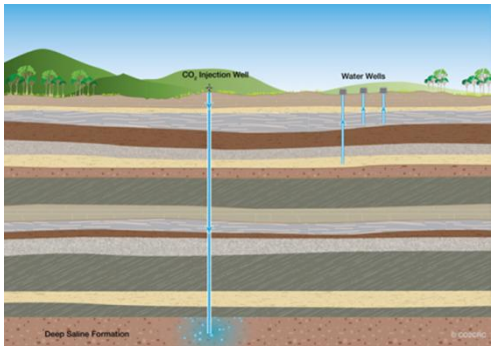
> Complement works

- Modeling and laboratory experimental to complement the study (EIFER, IGG-CNR)

WP2 (IFPEN) - CO2 storage behaviour



Influence of aquifer flow velocities

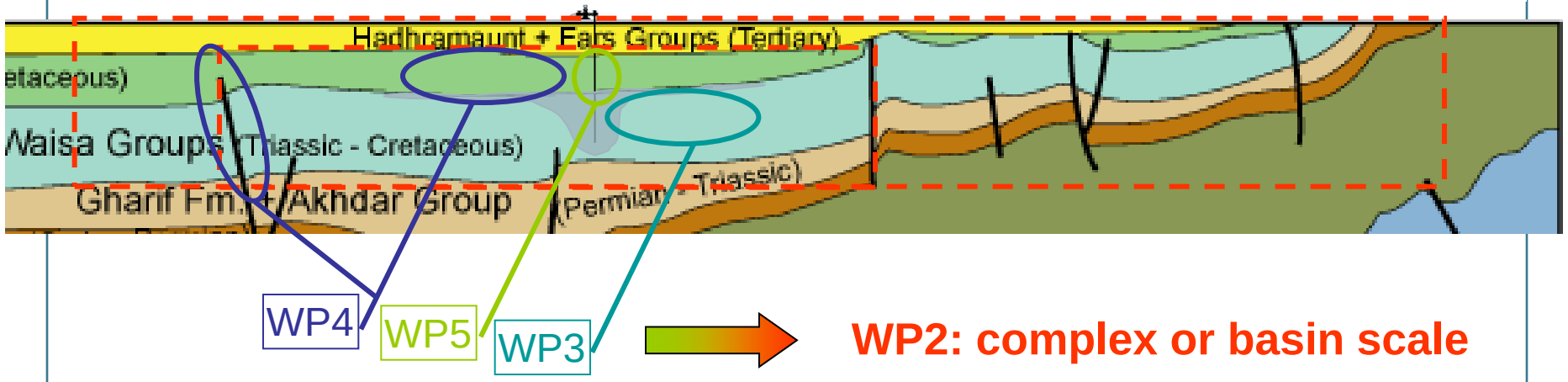


Impact of the CO2 injection on overlying fresh waters and brine migration

> Objectives

- Modelling the long-term CO_2 trapping mechanisms and brine migration at the complex or basin scale.
- Case studies based on selected demonstration sites (Hatfield and GeoLorraine).
- Integration of results from the other WPs so as to improved description of the long-term evolution at regional scale of:
  - physical processes affecting the storage formation (WP3),
  - sealing properties of faulted and fractured caprock formations (WP4),
  - sealing properties of wells (WP5).
- A case-study methodology combining numerical modelling and uncertainty assessment (WP6)

WP's to WP2 integration



- **Task 2.1**: Hydro-regional flow modelling of ground water displacement
- **Task 2.2**: Multi-scale modelling of the long-term CO_2 trapping
- **Task 2.3**: Assessment of sealing integrity of fractured caprock and faulted systems
- **Task 2.4**: Large scale assessment of leakages through wells
- **Task 2.5**: Uncertainties propagation from small to large scale

WP6 (PHIMECA) – Uncertainty assessment

General objectives of uncertainty assessments

"What is the **best estimate value** of the model prediction?"

"What **level of confidence** can I associate to my result?"

"What sources of uncertainty are the **most important** to account for?"

"What **effort** should I spent to characterize a parameter?"

WP6 – Uncertainty assessment

Challenges for uncertainty assessment within ULTIMATE-CO2

- Times scales: long term ➔ prediction >100 years
- Spatial scales: lab scale➔ near well zone ➔ reservoir formation ➔ regional scale
- Multiple processes ➔ multiple input parameters (10-100)
- Data: lab, in situ tests, literature, experts' judgements, etc. ➔ heterogeneity of quantity and quality of information
- Models: analytical, semi- analytical, numerical, intensively parallelized codes, etc…

WP6 – Uncertainty assessment

- **Objective**: to provide a general methodology for uncertainty assessment that is applicable to the geophysical systems involved for CO2 storage and to implement application examples.

- **Task 6.1**: A state-of-the-art of norms and uncertainty assessment approaches will be first provided while some key points such as the modelling of spatially random parameters and the account for epistemic uncertainty will be investigated.

- **Task 6.2**: the implementation of the proposed framework will be addressed in close connection with the work packages 2-5. For this purpose, simulation models will be selected in each WP, for which a sensitivity and uncertainty assessment will be carried out using surrogate (response surface) models approach.

WP7 (CO2SENSE) - Dissemination

> Objective

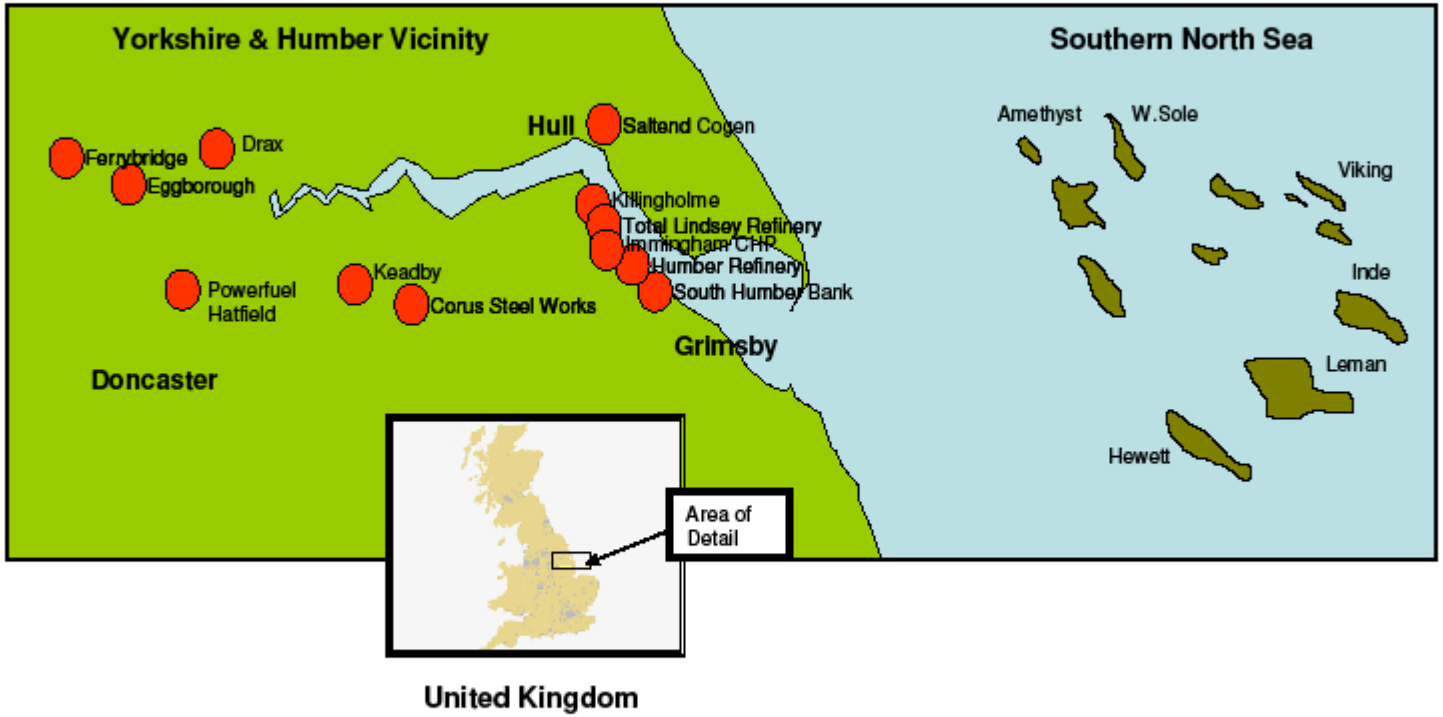
- To produce overall project recommendations from activity in the RTD WPs 2,3,4,5 and 6.
- To disseminate project results to five stakeholder groups; policy makers & regulators, investors, CO2 storage developers, the scientific community and the general public.
- To increase each stakeholder group's understanding of the efficiency, safety, and uncertainties of the long-term evolution of CO2 geological storage.
- To enable exploitation of project results by each stakeholder group.

> **Tasks** :

- ULTimateCO2 website and virtual networks
- Project dissemination and media interaction
- Development of results and project recommendations

Pilot sites (WP3 and WP2)

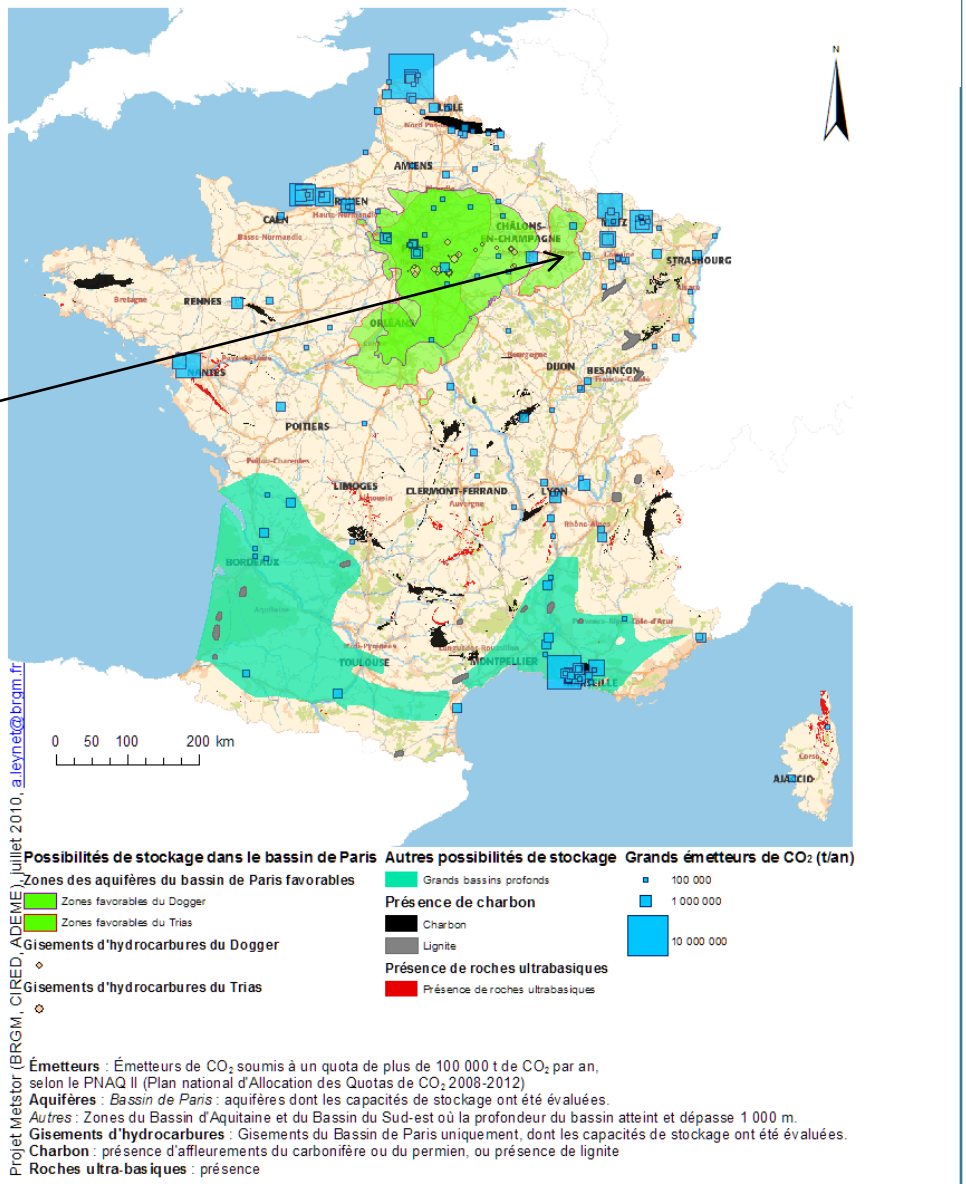
- **Off shore EEPR Don Valley site (UK),**
- **Operated by National Grid**



Pilot sites (WP3 and WP2)

- **On Shore GeoLorraine candidate for NER300 project (France)**
- **Operated by Arcelor Mittal**

Zones potentiellement favorables au stockage du CO_2 en France



Thank you…

Questions…?

WP6 – Uncertainty assessment

- **Task 6.1 Uncertainty methodology: state-of-the-art and adaptation to geosystems (BRGM, TNO, Phimeca)**
  - Assessment of sources of uncertainty (TNO)
  - Representation of epistemic uncertainty using modern uncertainty theories (BRGM)
  - Representation of spatial variability of parameters (BRGM)
  - Surrogate models for uncertainty propagation and sensitivity analysis (Phimeca)
- **Task 6.2 Uncertainty assessment: implementation (Phimeca)**
  - Implementation of uncertainty and sensitivity for WP2-5