PilotSTRATEGY

Onshore CO_2 Storage in the Paris Basin: An Overview of Geological, Technical, and Social Studies

Autumn webinar, 7th November 2024

The PilotSTRATEGY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022664

General Introduction

PilotSTRATEGY Project – H2020 Project

PilotSTRATEGY

https://pilotstrategy.eu/

- Preliminary study with **objective to propose CO_2 Storage Pilots** in strategic territories (2021-2026)

French Team
(5 partners + 3 third-party)
~ 4,2 Million € for France

Coordinator

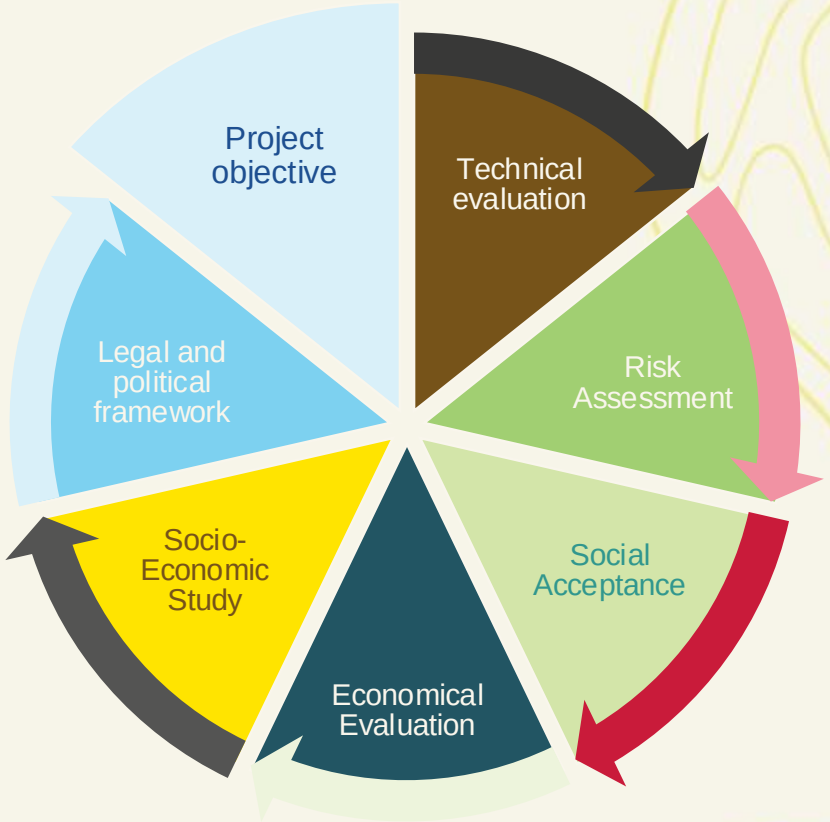
brgm – Géosciences pour une Terre durable
IFP Energies nouvelles
Geostock
SYMLOG
avenia
arverne

PilotSTRATEGY Project – H2020 Project

- **Main Objective**: provide a detailed study of a **Saline Aquifer** and its seal, with the objective to propose a pilot for CO_2 Storage

- Look at **all parameters** for CO_2 Storage
  - Geological / Technical / Social / Legal / Economical

- Complete study to propose a **Pilot**



Research project including all aspects for CCS

Project organisation

WP7 Communications & Impact

brgm

WP2 Geo-characterisation

brgm, IFP Energies nouvelles

WP6 Social Acceptance

SYMLOG

WP3 Simulation

brgm, IFP Energies nouvelles

WP5 Safety

brgm

WP4 Pilot Development

Geostock

Project time line

- Seismic data acquisition
- Sedimentological description and petrophysical measurements
- Historical data enhancement

Subsurface data acquisition

- Develop numerical model which attempts to represent subsurface reservoir complex

Static modelling of the reservoir complex

- Predict reservoir behaviour during CO_2 injection, CO_2 plume evolution , pressures, etc…

Dynamic simulation with CO_2 injection

- Optimised well location
- Scenarios evaluation
- Environmental and economic assessment

Pilot conceptualisation

Risk assessment

May 2021 | **May 2023** | **May 2024** | **May 2025** | **May 2026**

Discussion and exchanges with stakeholders

Who is the French Team ?

brgm

Aurélien Bordenave
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Fernanda Veloso
Thomas Le Guenan
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Sylvain Stephan
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Nicolas Gilardi
Alexandre Stopin
Benoit Issautier
Michael Delatre
Simon Andrieu
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IFP Energies nouvelles

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Alexandre Fornel
Marc Fleury
Damien Bonte
Jeremy Frey
Axelle Baroni
Axelle Alavoine
Clémentine Meiller

Geostock

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Hubert Jannel
Romain Bocquet
Fabio Coutand
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SYMLOG

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Marc Poumadère

avenia

Emmanuelle Robins
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S3 smart seismic solutions

Julien Wallendorf
Patrick Robert

VERMILION ENERGY

Chaker Raddadi
Sophie Palu

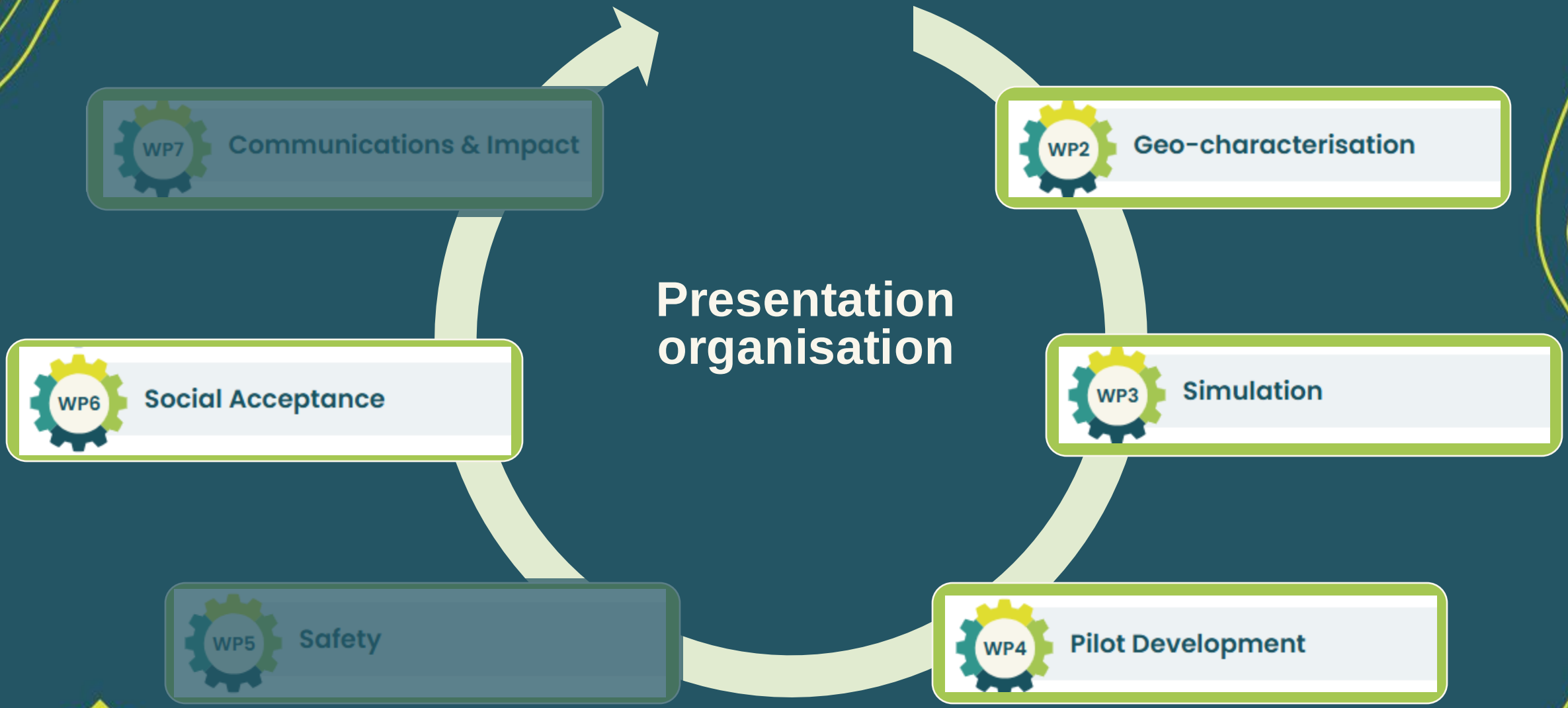
arverne GROUP

Guillaume Tarnaud

⇒ **Over 35 participants involved in the project**

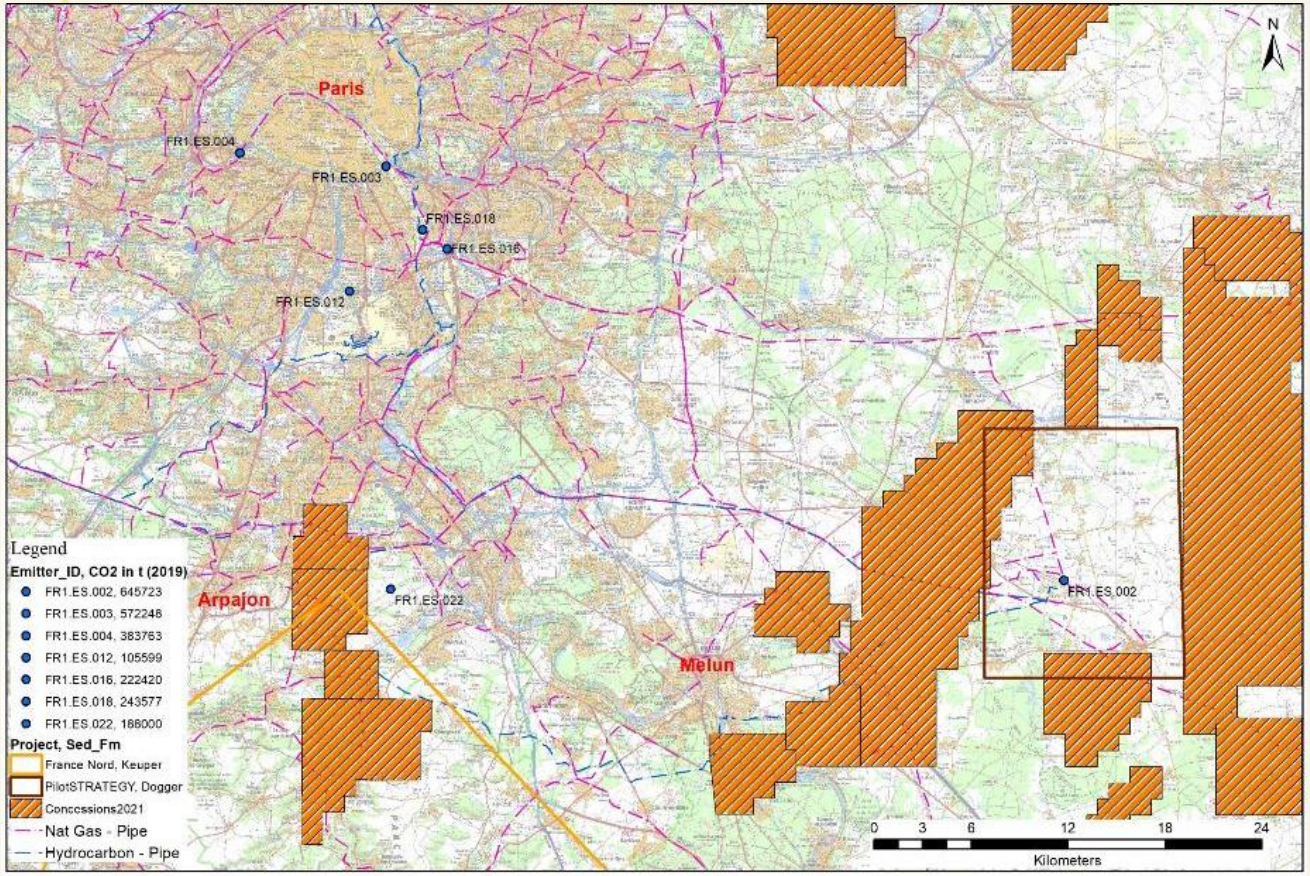
Many thanks to them for their contributions

Presentation organisation



Presentation organisation

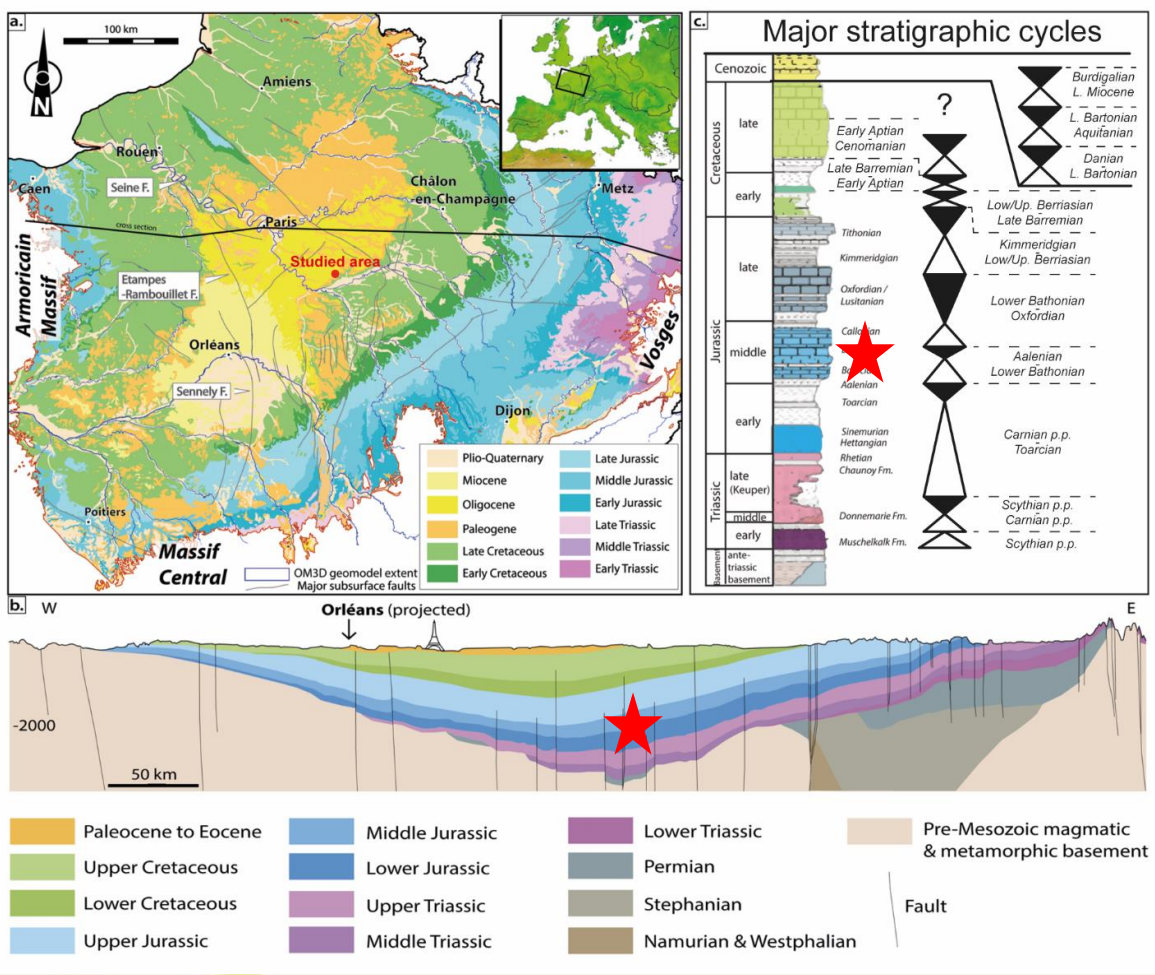
Selection of the Study Area – Paris Basin

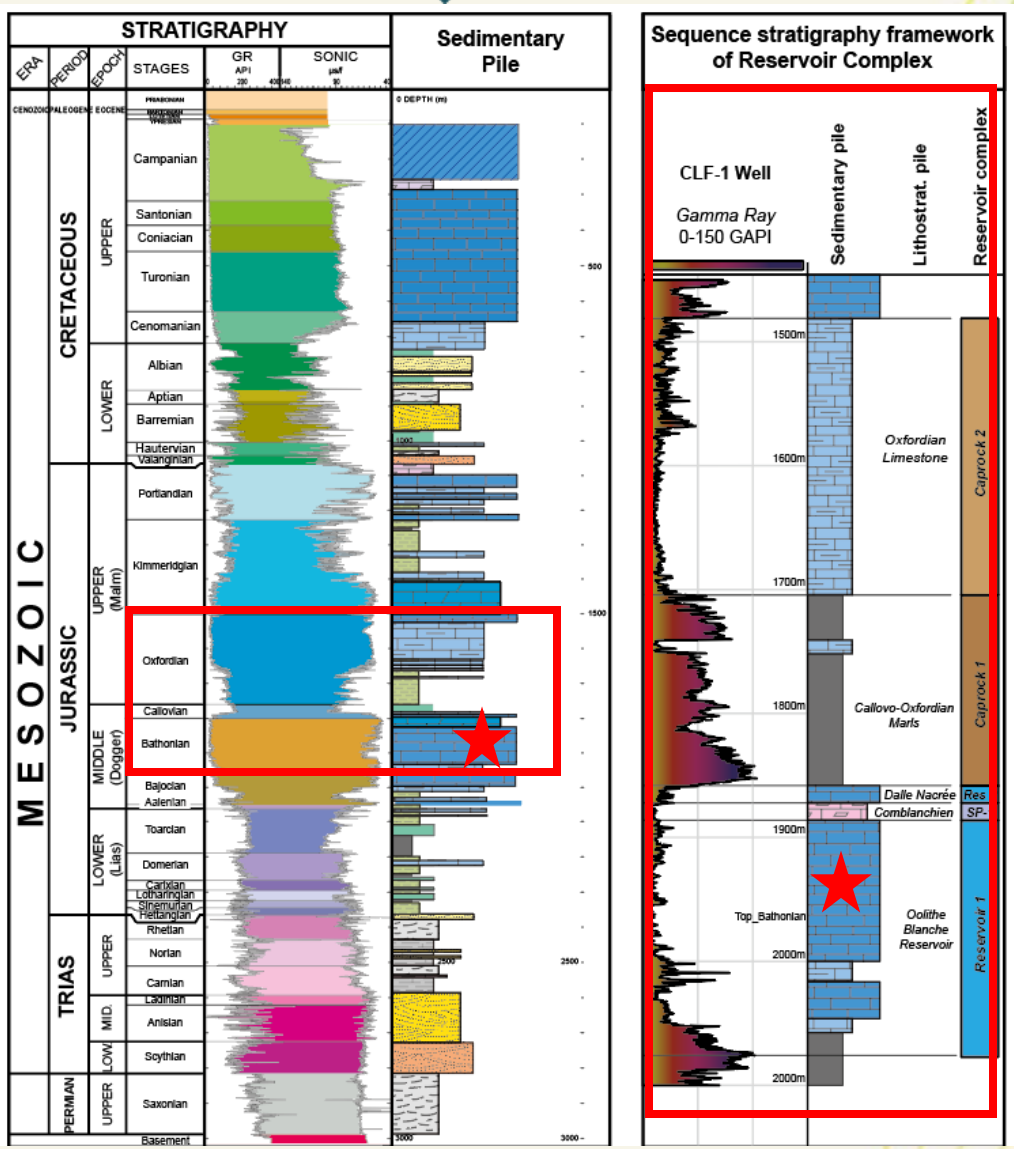


- **Geographical area**
  - Nangis
- **Geological target– Dogger reservoir**
  - Historical reservoir for O&G and Geothermal
  - Saline Aquifer in Carbonate reservoir
- **Emitter**
  - Fertilizer plant with 300 kt/y CO_2 captured
- **Available data**
  - Extensively explored and produced (O&G)
  - New seismic data (3D)
- **CO_2 storage capacity estimation**
  - Sufficient preliminary estimation for a pilot test

General context

Paris Basin and Dogger Reservoir Complex

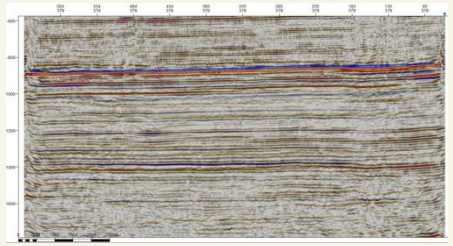




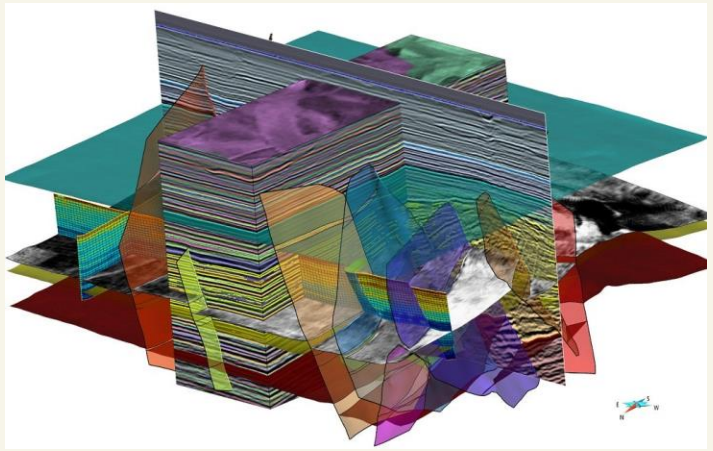
Mas et al., 2022

Multi-dataset and analyses for one purpose

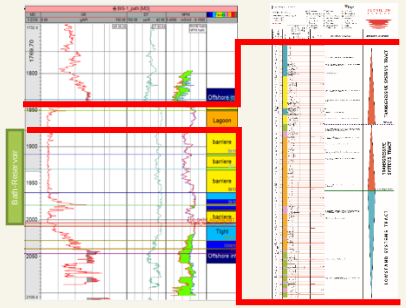
Seismic data
Subsurface geometry



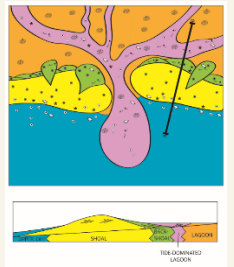
WP3 Simulation



Plug samples
Rock properties and reactivity with CO_2 injection



Well log and core descriptions
Detailed reservoir facies partitioning



Historical dataset and new interpretations

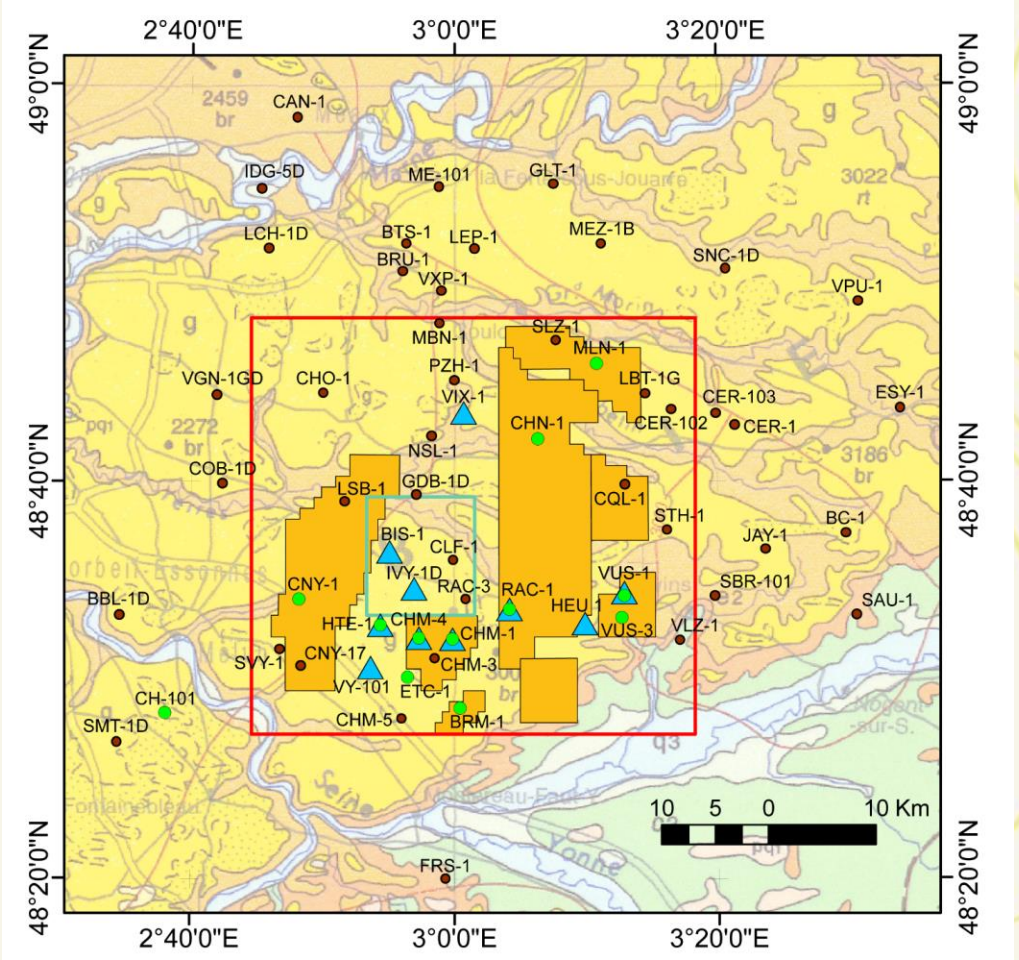
Well log data: ●

- 47 wells – O&G exploration and production (70’ & 80’)
- Full set of wireline logs (GR, Rhob / Nphi, SP, DT, CAL, ILM, ILD…)

Cores: ▲

- 477 metres divided into 12 wells
- Dalle Nacrée / Comblanchien / top Oolithe Blanche Fm.
- High frequency sequence stratigraphy study

- **Thin sections** ●
  - Most sampling from topmost reservoir
  - 240 thin-sections divided into 12 wells
- **Plug**
  - Primarily from topmost reservoir interval
  - K/Phi measures – 470 plugs sur X wells



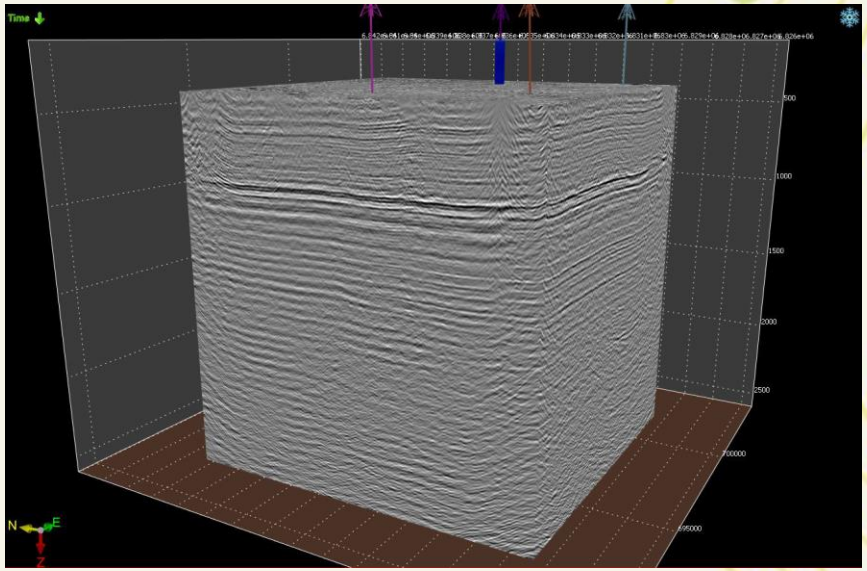
Confidential

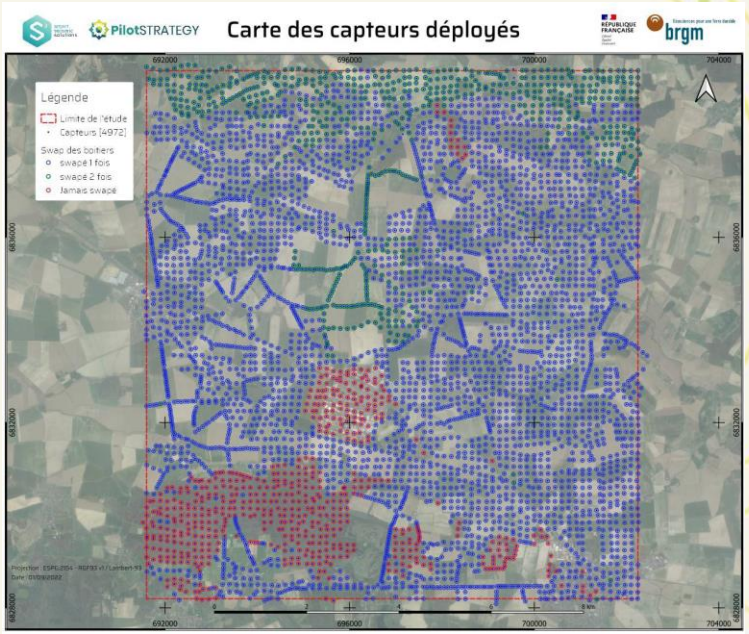
WP2 - Geocharacterisation

Newly acquired 3D seismic data

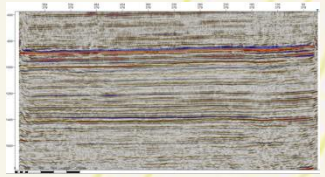
Vibrateur PRAKLA 16t x3

Vibrateur Mertz 27t x3



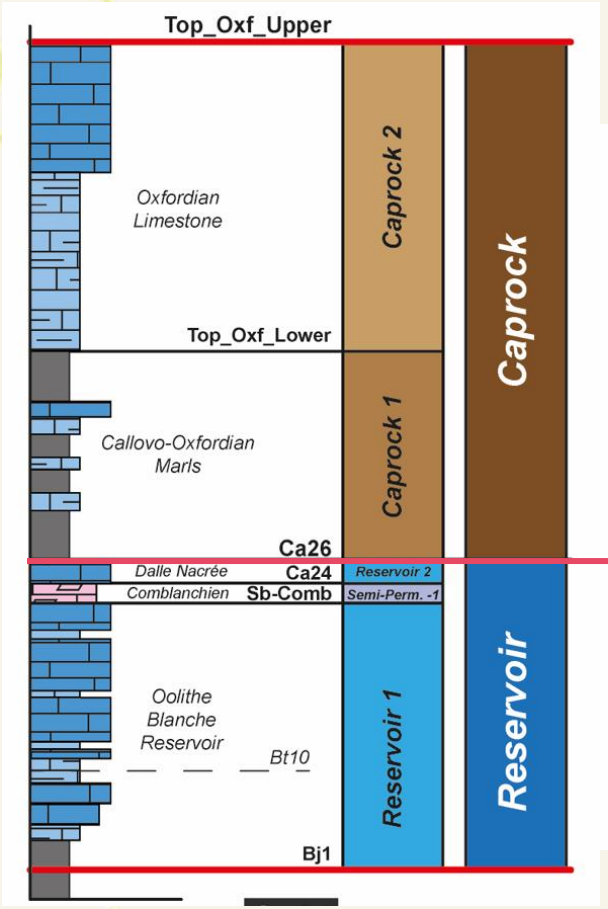


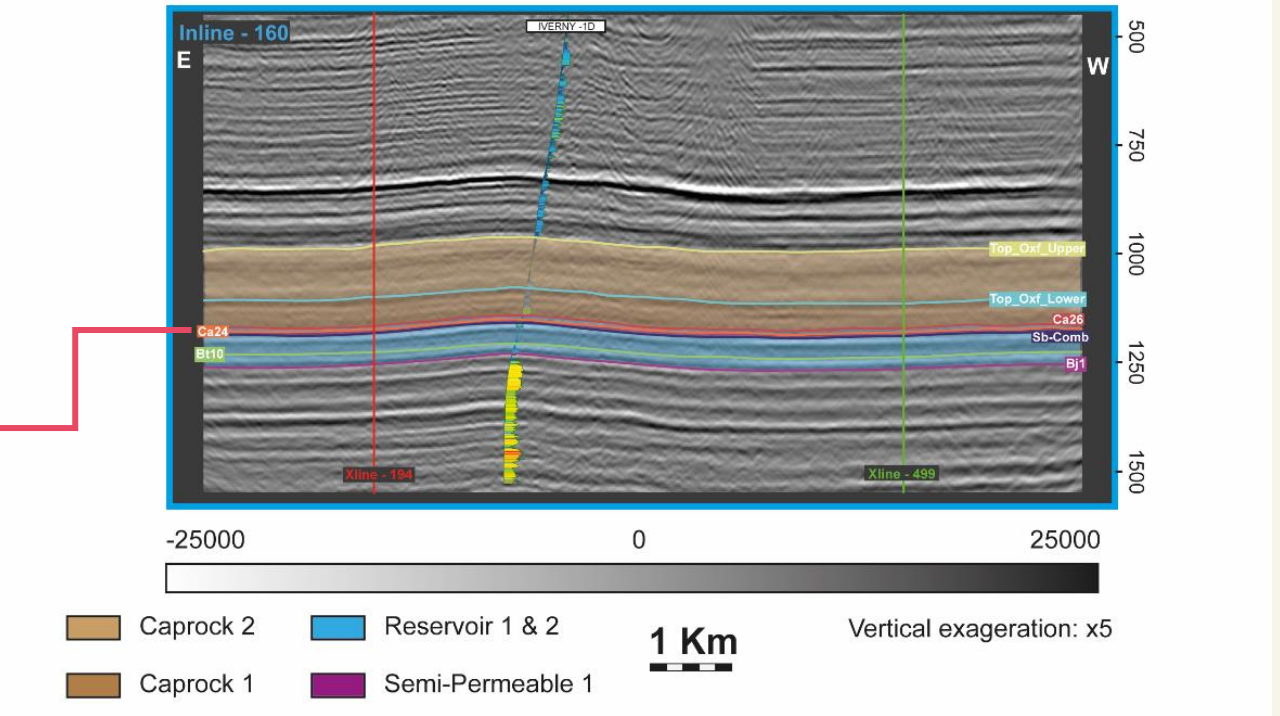
- **Involvement of the public and public authorities**
  - Meetings with various partners (Local, regional, governmental authorities, Chamber of Agriculture)
  - Public meetings with scientific presentations and showcase
  - Specific tests on old drains which cover the area

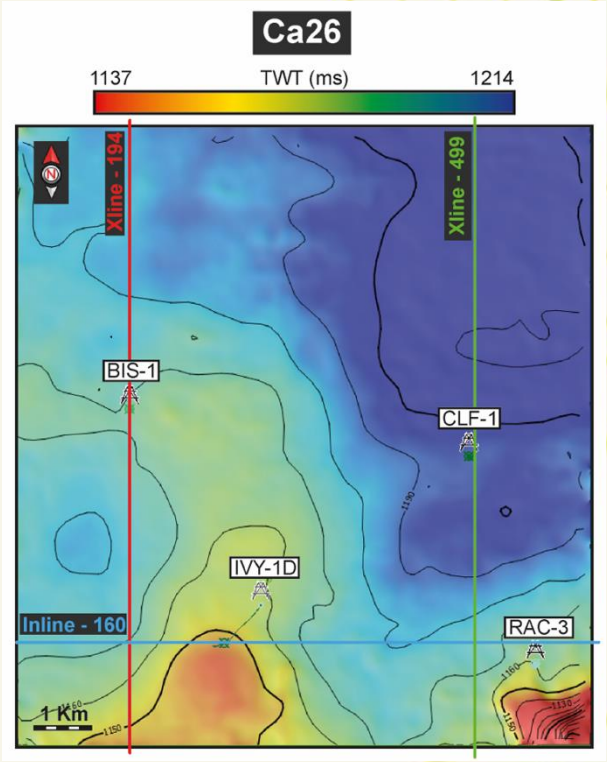


WP2 - Geocharacterisation

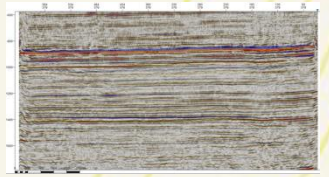
3D seismic data => Complex reservoir Geometry







1680 to 1767m SSTVD



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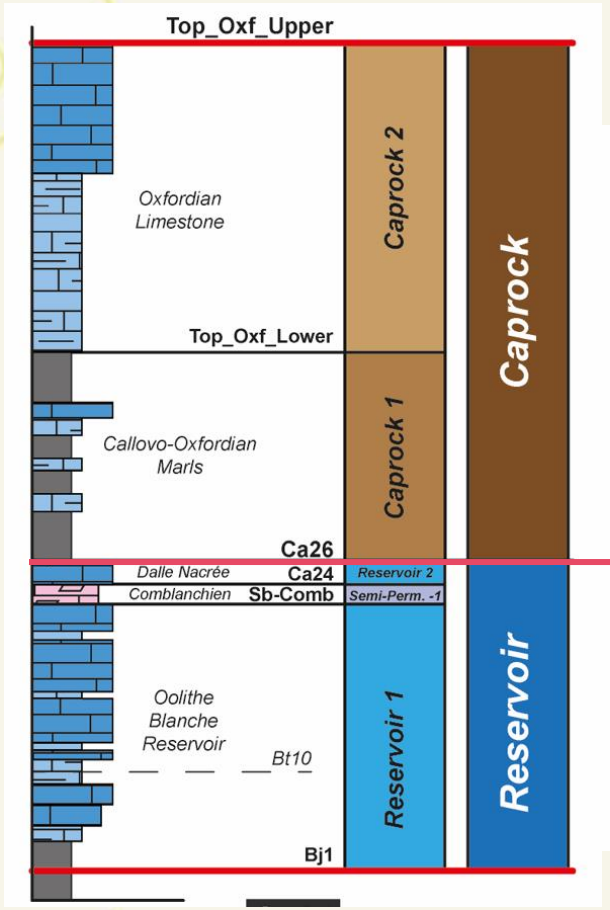
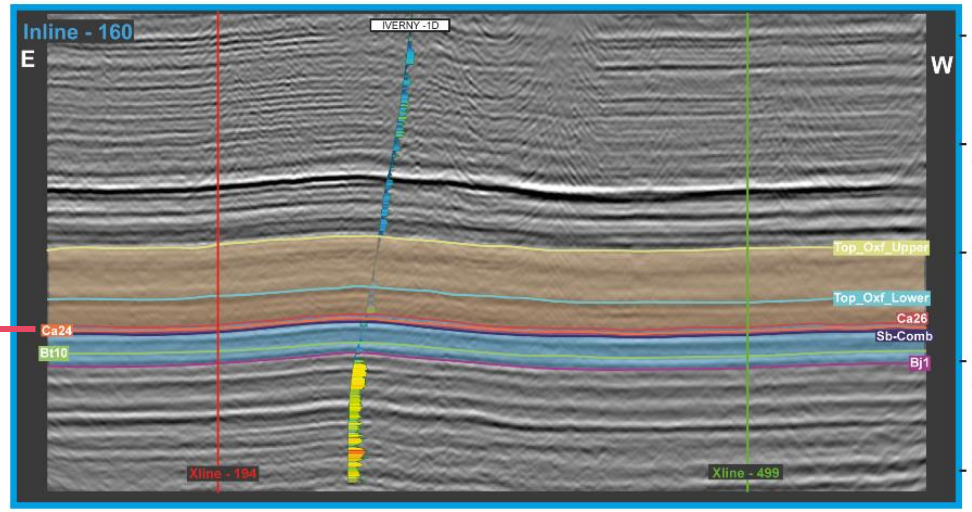
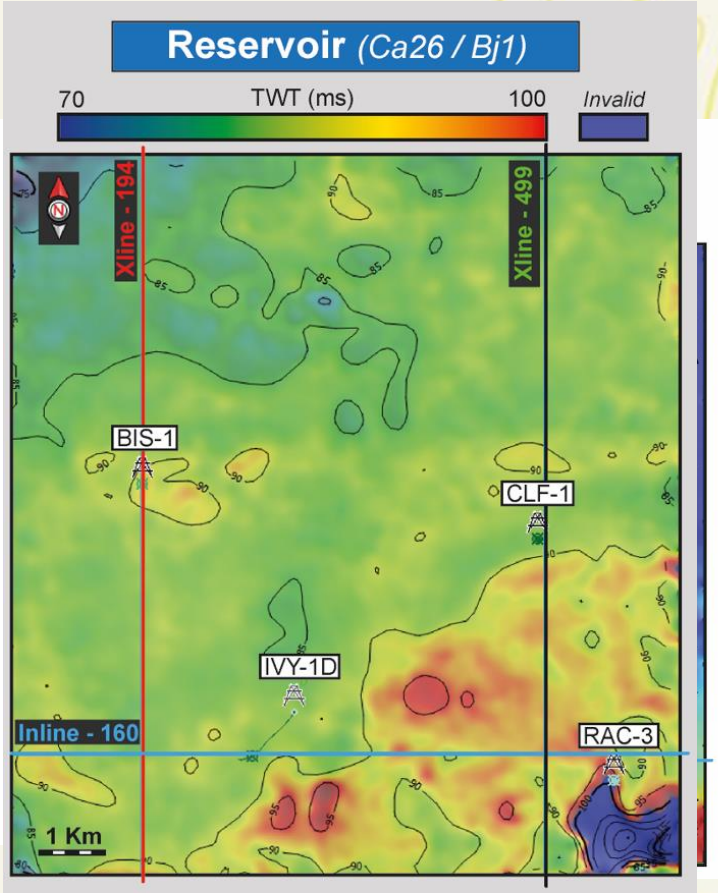
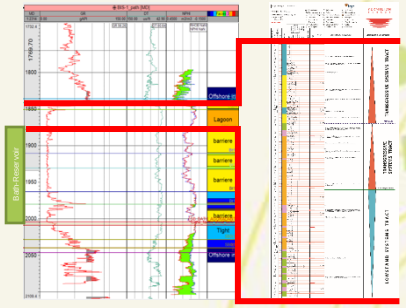






163 to 240m thick

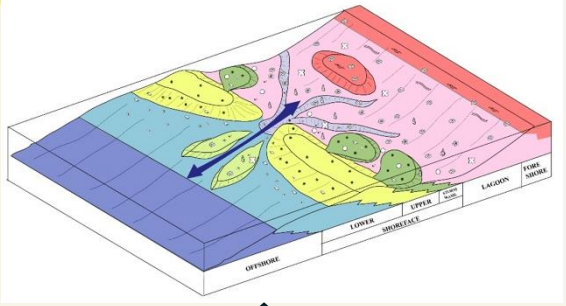
Well log and core descriptions
Detailed reservoir facies partitioning



WP2 - Geocharacterisation

From cores to depositional environment model

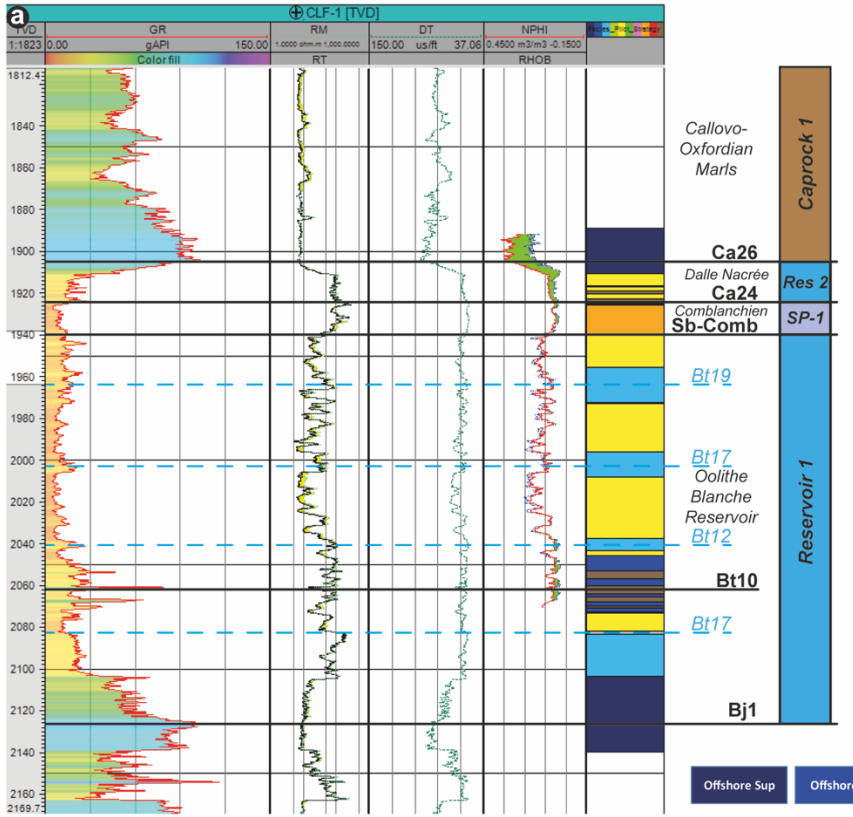
Conceptual geological model

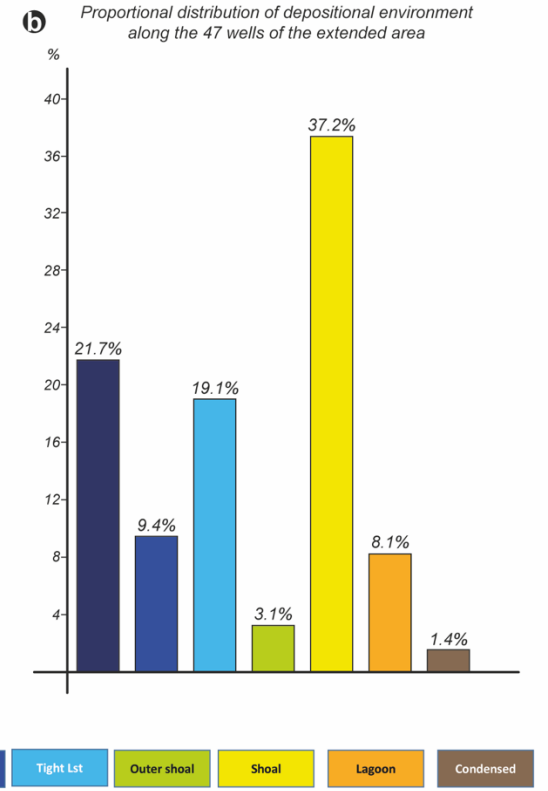


From Core Description

Sequence stratigraphy correlation

Well log interpretations / Electrofacies…



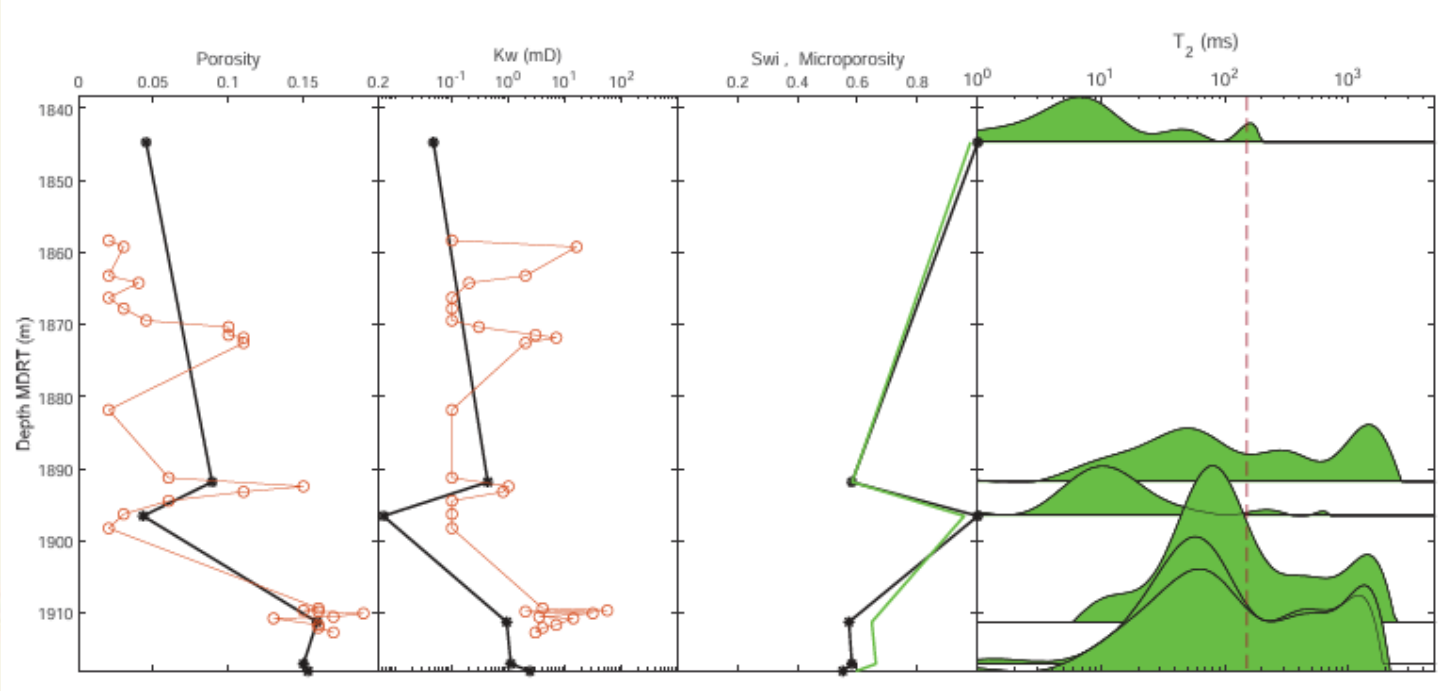


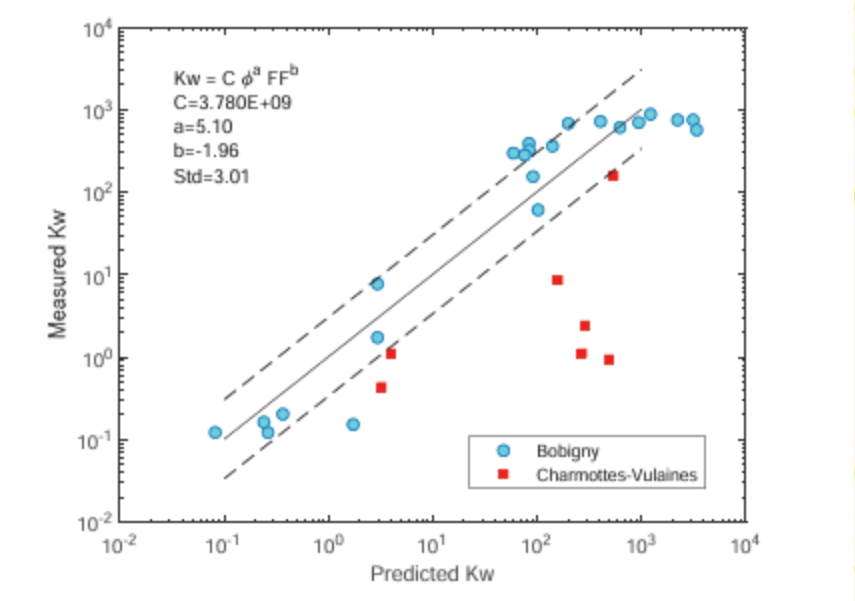
Plug samples
Rock properties and reactivity with CO_2 injection

WP2 - Geocharacterisation

Rock properties => Reservoir & Mechanic

7 new samples + important database (>400) in reservoir section
=> K/PHI law for each reservoir part
=> New core discovery and study on the full complex reservoir





Multi-dataset and analyses for one purpose

Seismic data
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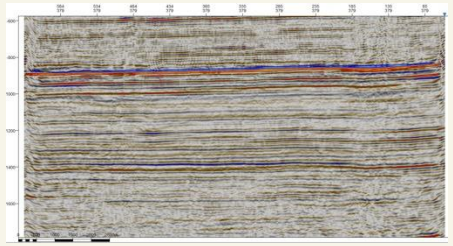
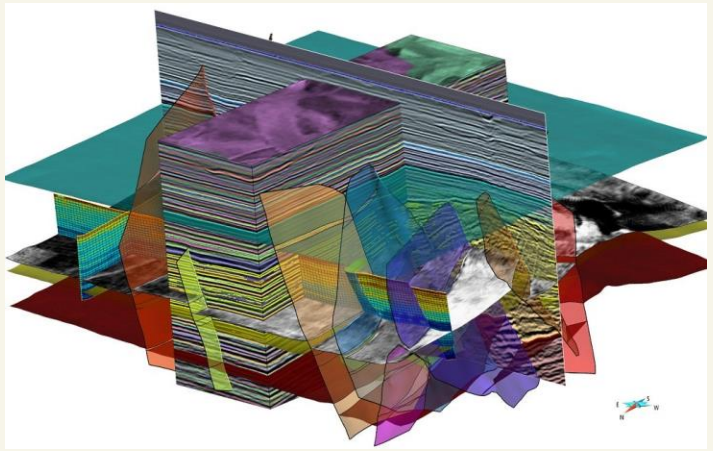


WP3 Simulation



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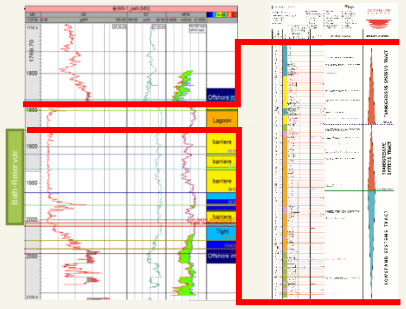
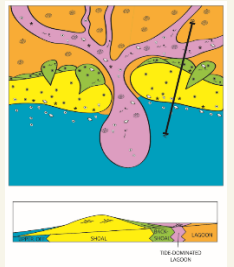


Well log and core descriptions
Detailed reservoir facies partitioning



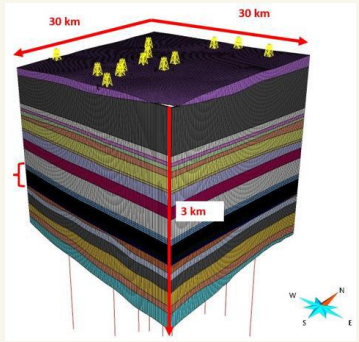
Presentation organisation

WP3 - Simulation

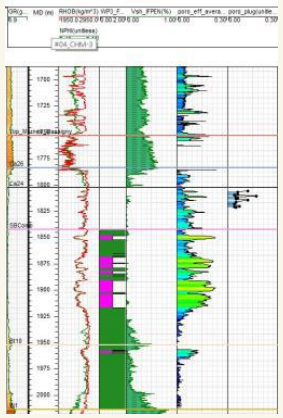
Static modelling General workflow

1

Grid Construction
from seismic and well markers

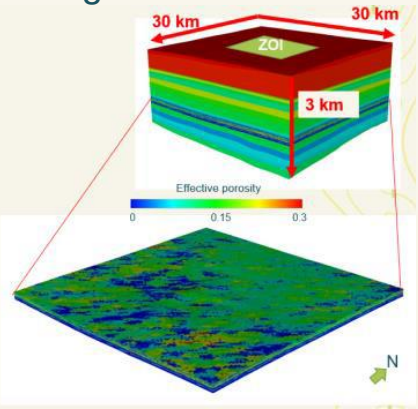


Interpretation of well data (log & core data)

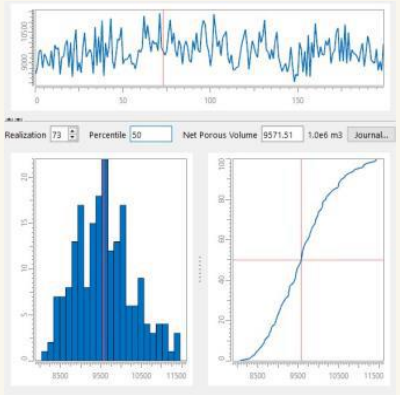


2

Facies and Petro-physical Modelling
With geostatistics

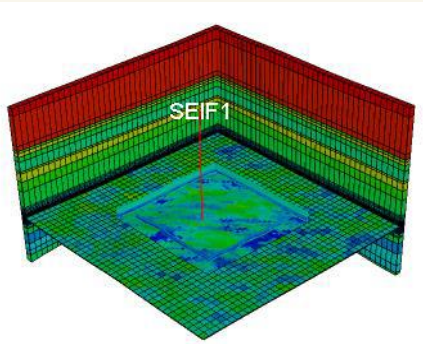


Uncertainty analysis, Net Porous Volume (P10, P50, P90)



3

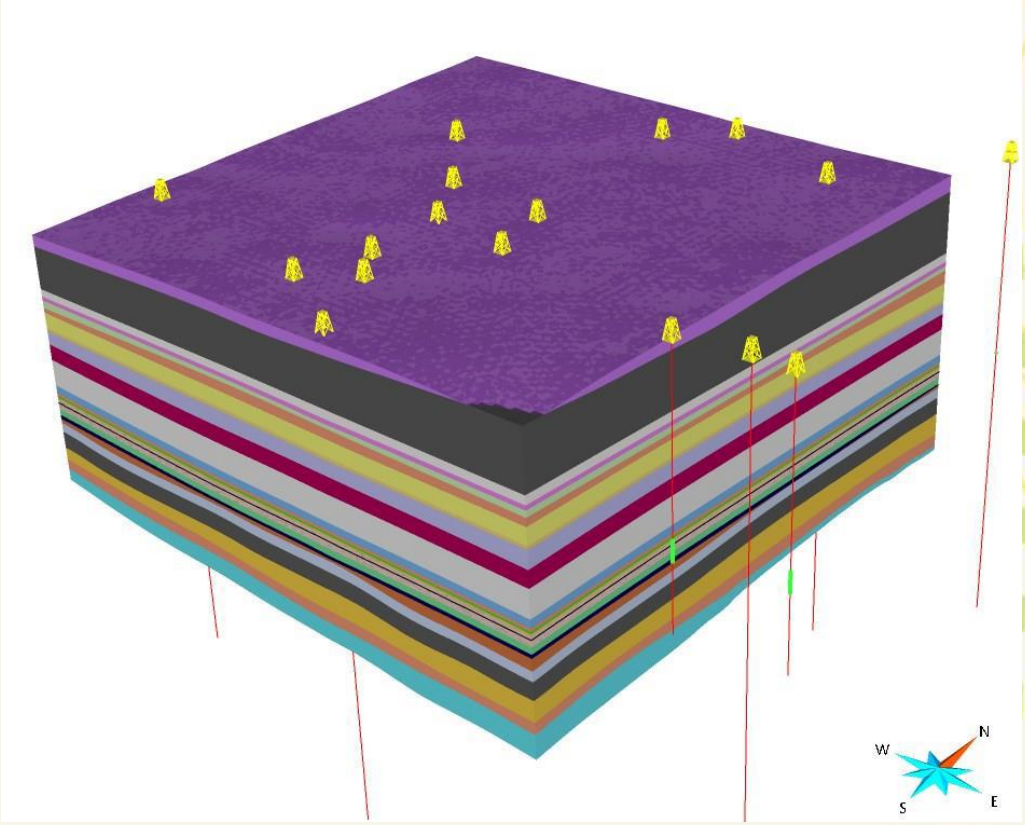
Upscaling and LGR



WP3 - Simulation

Static modelling => Grid construction

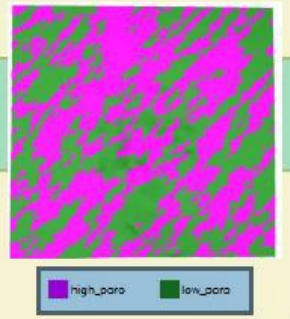
- Static geological model with **24 layers**
- **30x30 km² extension**, ZOI 10x10km² with seismic data
- 250m cell size
- Coarse scale resolution in the over-and underburden, **fine resolution** in the **reservoir and seal** complex
- Vertical resolution for the **seal: 5m**
- Vertical resolution for the **reservoir units: 2-3m**
- **Geostatistical modelling** of effective porosity and permeability in reservoir and seal
- **Principal reservoir** for CO_2 storage is **Oolithe Blanche Fm.** - mean porosity 10.25% (15% in Oolitic bodies)



WP3 - Simulation

Static modelling => petrophysical modelling workflow

Facies modeling



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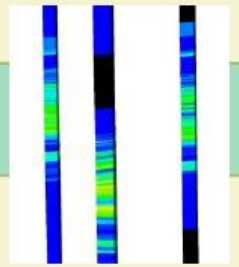
Blocking well logs



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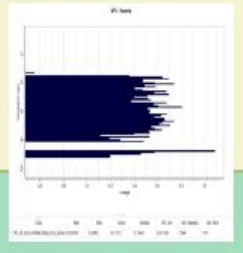
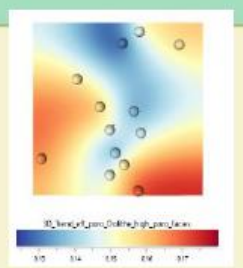
Trend analysis





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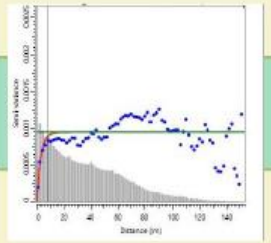
Variogram modeling



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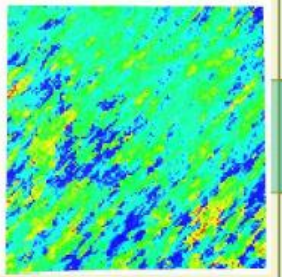
Porosity modeling



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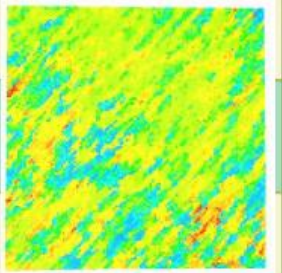
Permeability modeling



WP3 - Simulation

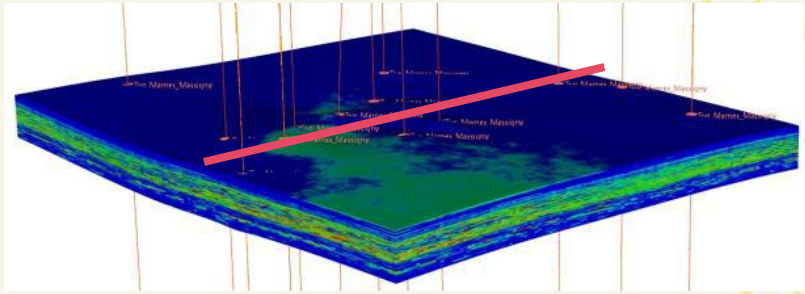
Static modelling => petrophysical modelling workflow

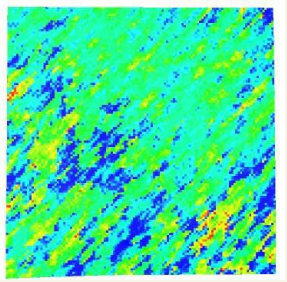
Porosity :

- Using a Sequential Gaussian Simulation with data from well / porosity distribution/ variograms and 3D trend data.

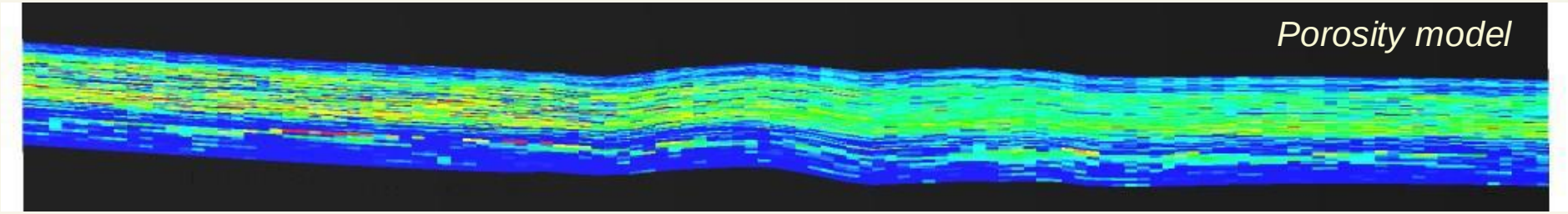
Permeability:

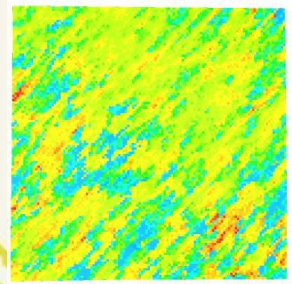
- Calculation of K-Φ laws from plug data (444 measurements) from 8 wells (4 inside the grid) using linear regression model (1 law per facies / Formation)



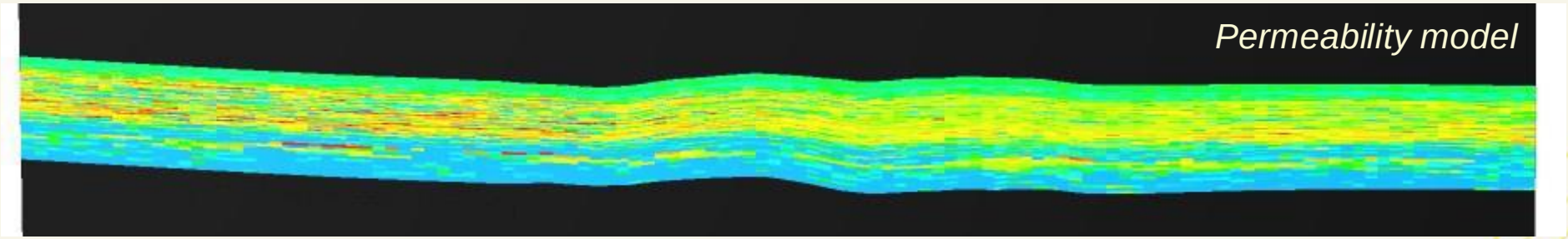


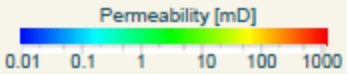
k = 38





J = 60





WP3 - Simulation

Static modelling => Upscaling & LGR

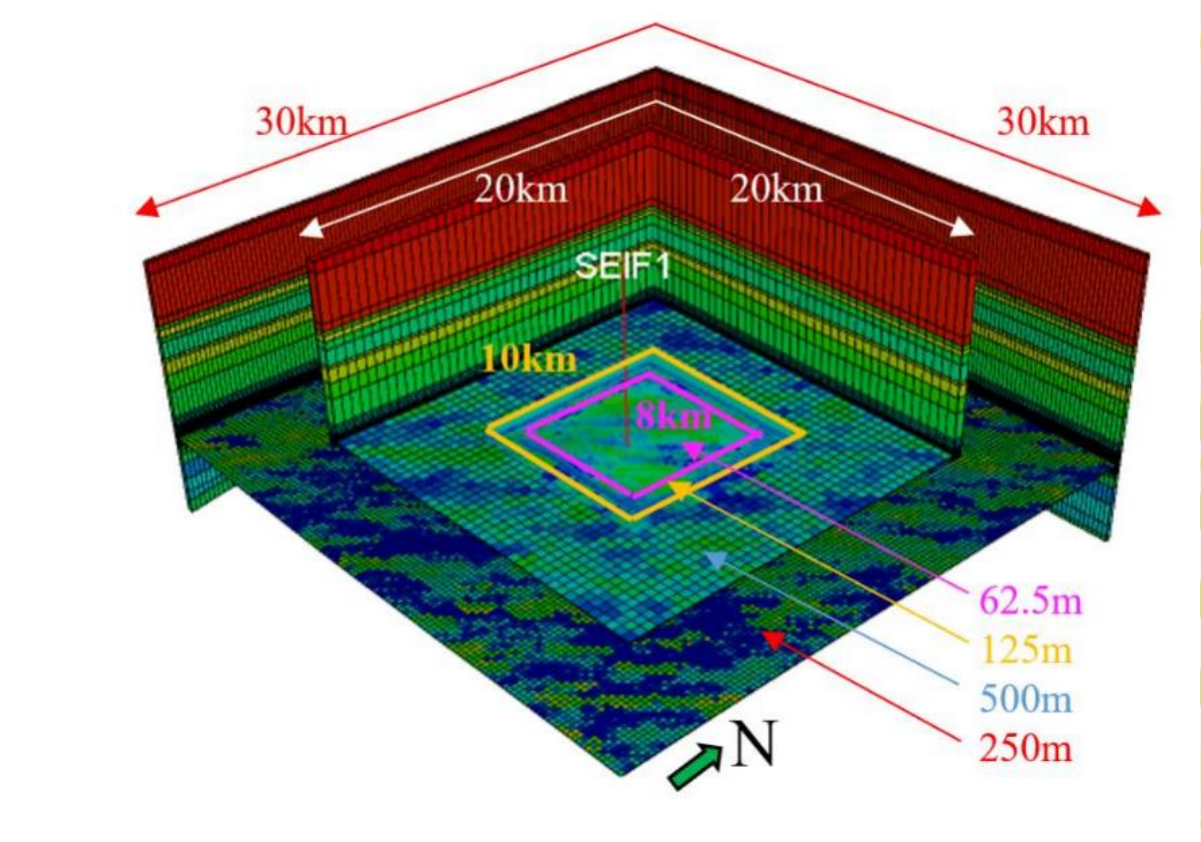
Horizontal (coarsening and LGR)

3 levels of discretisation (2 embedded LGRs)

From 0 to 10 km & 20 to 30 km (X-& Y-direction)
-->500 x 500 m (==> 20x20 *2 + 20x60 *2 cells)

From 10 to 11 km & 19 to 20 km (X-& Y-direction)
-->125 x 125 m (==> 4x80 *2 + 4x72 *2 cells)

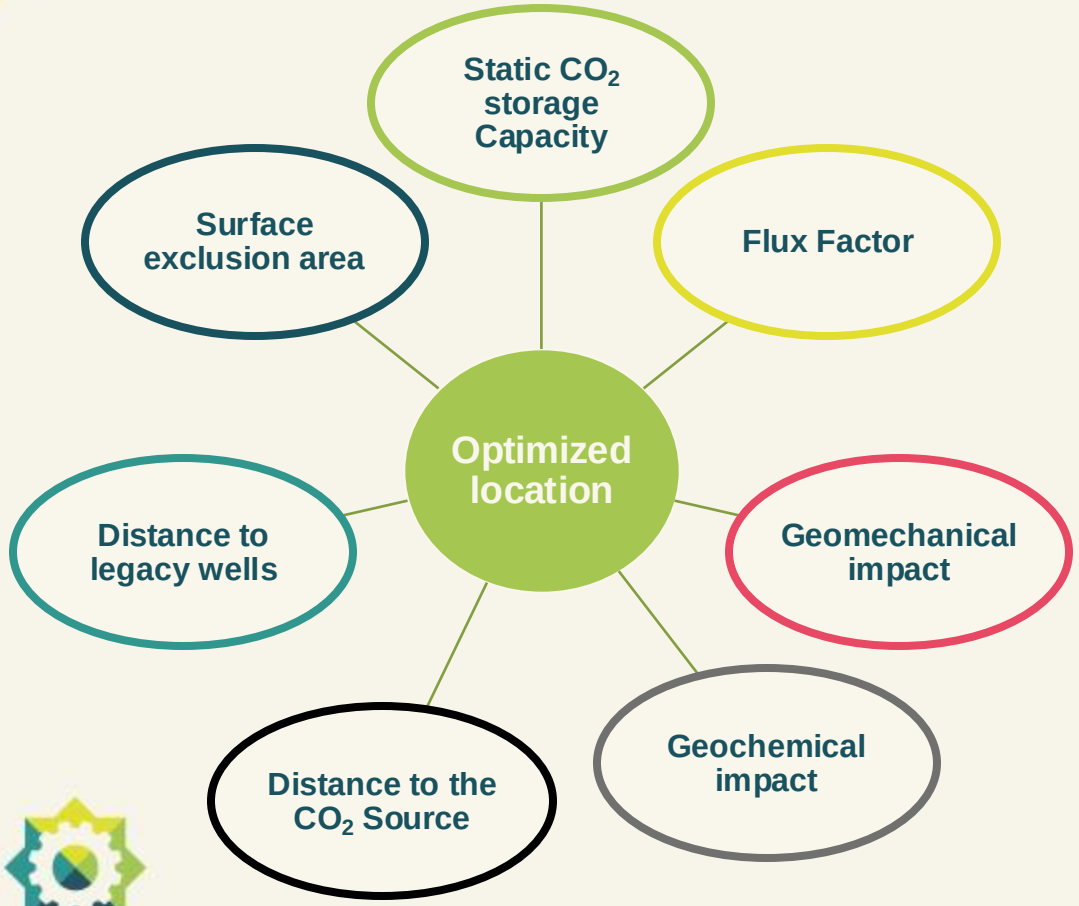
From 11 to 19 km (X-& Y-direction)
-->62.5 x 62.5 m (==> 128*128 cells)

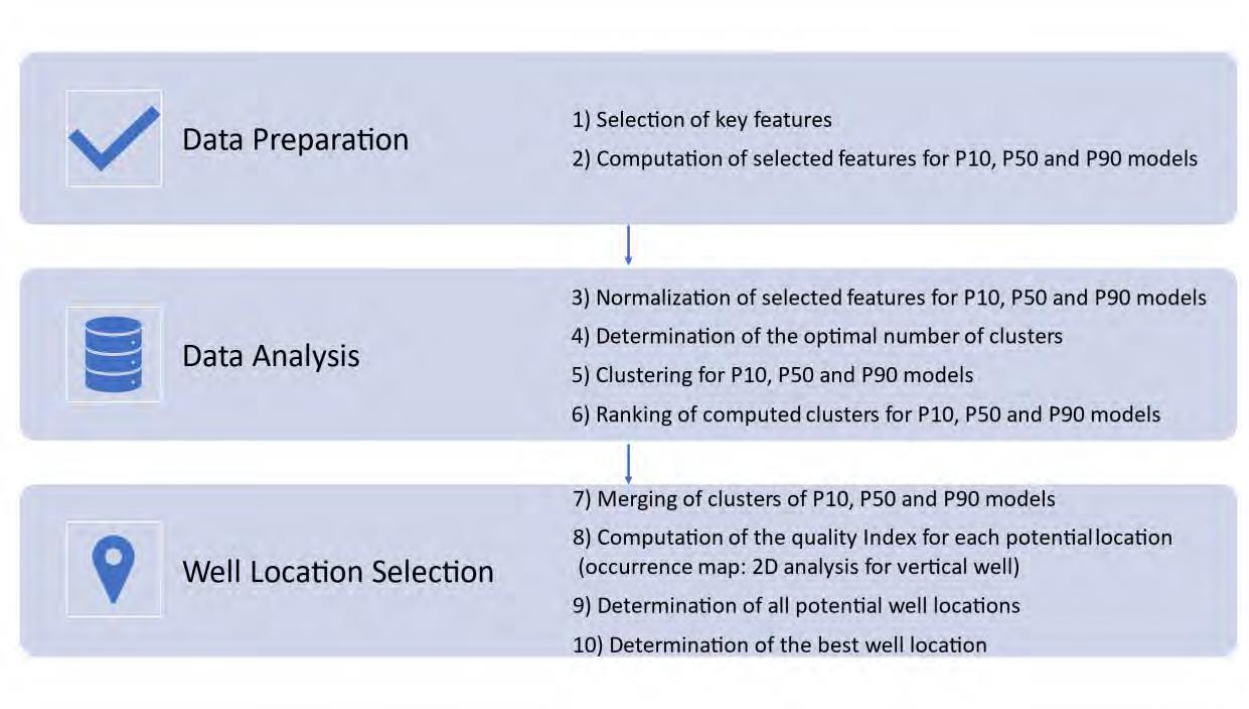


WP3 - Simulation

Well location optimization

Methodology adapted from Fornel (2014)

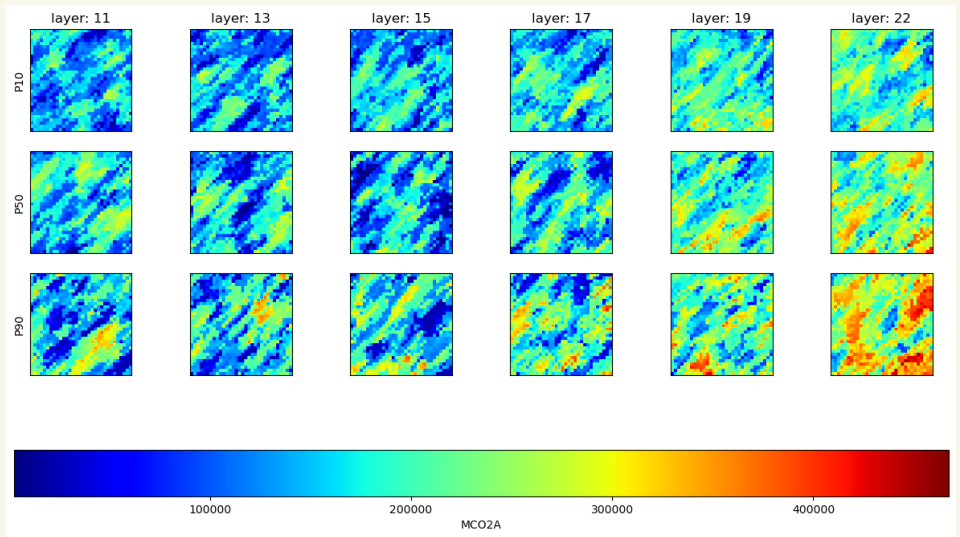




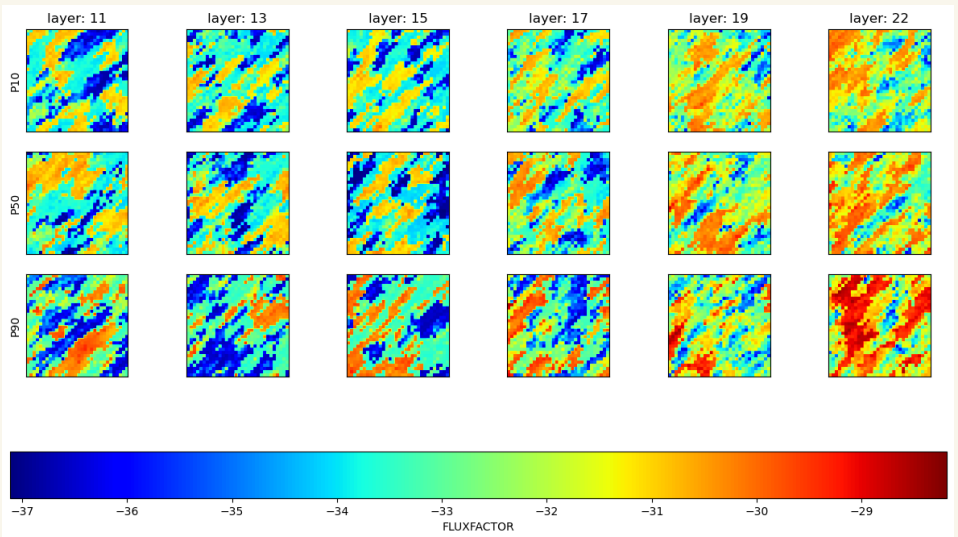
WP3 - Simulation

Well location optimization

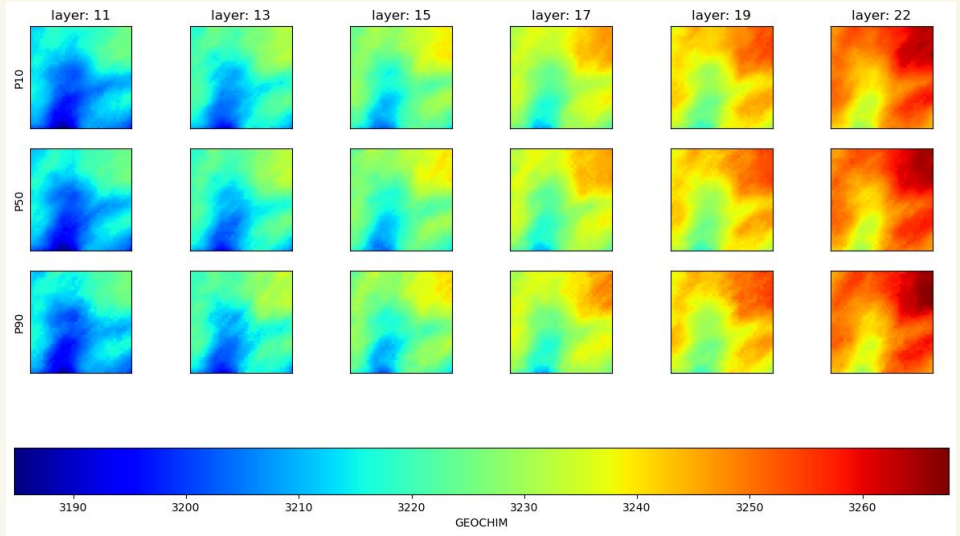
Static CO2 storage Capacity



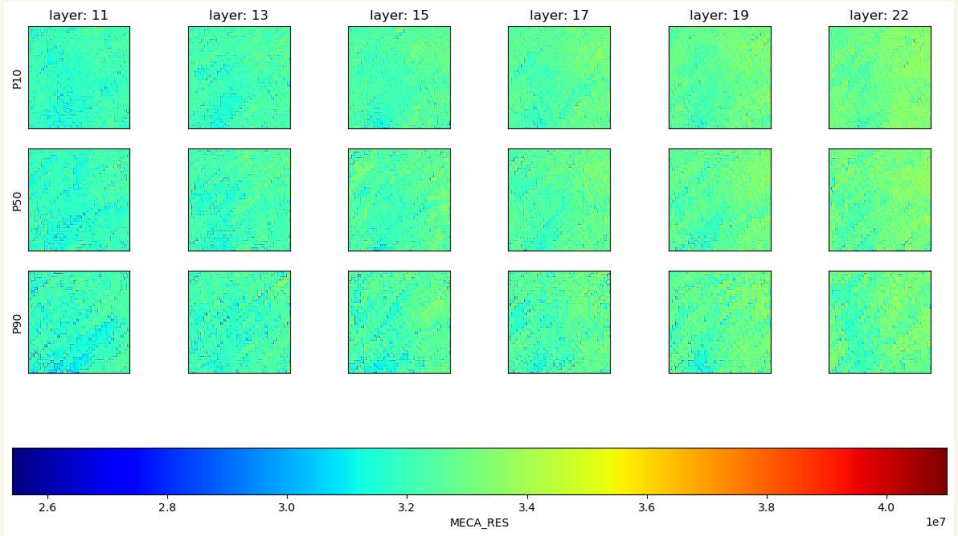
Flux Factor



Geochemical impact



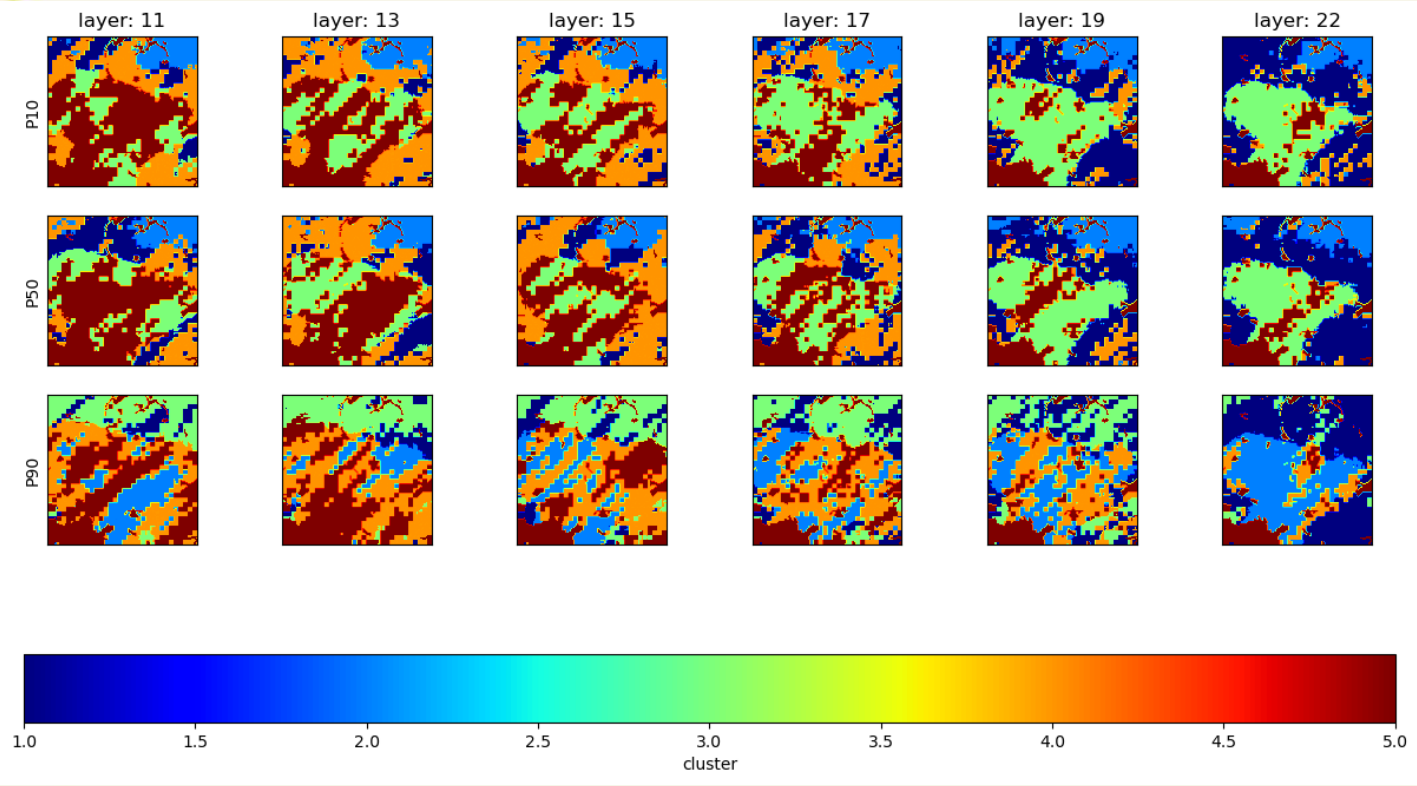
Geomechanical impact



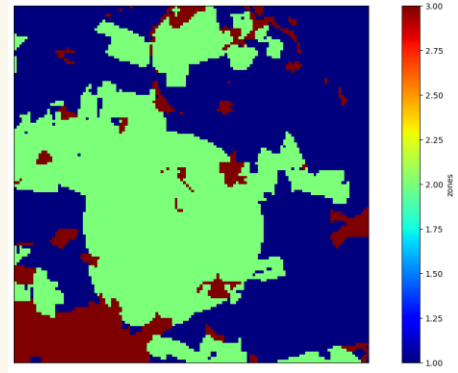
WP3 - Simulation

Well location optimization

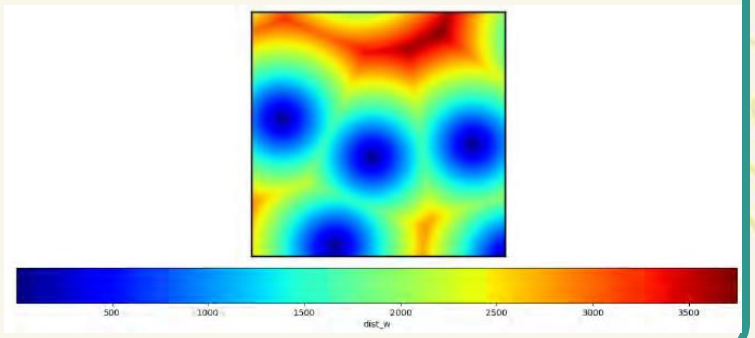
Clustering results for each model P10 / P50 / P90



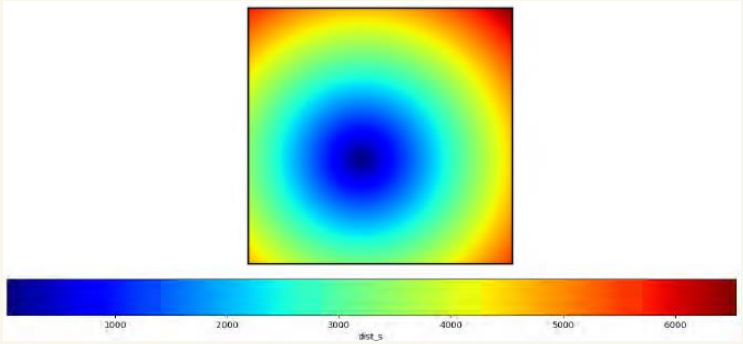
Surface Exclusion area



Distance to legacy wells

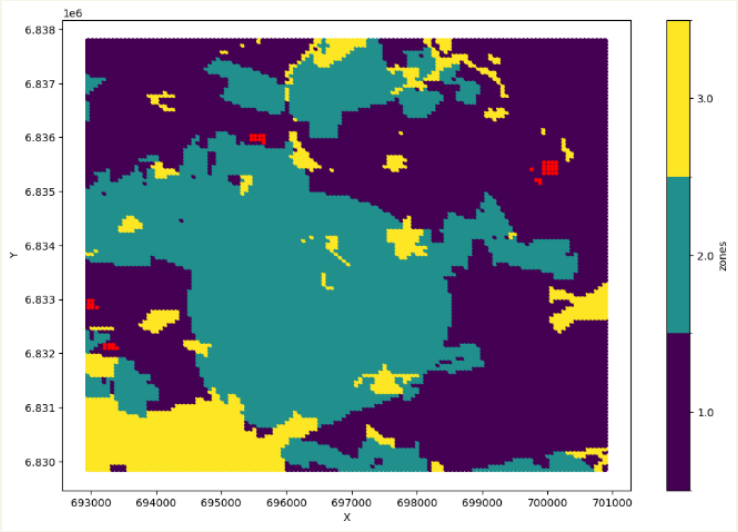


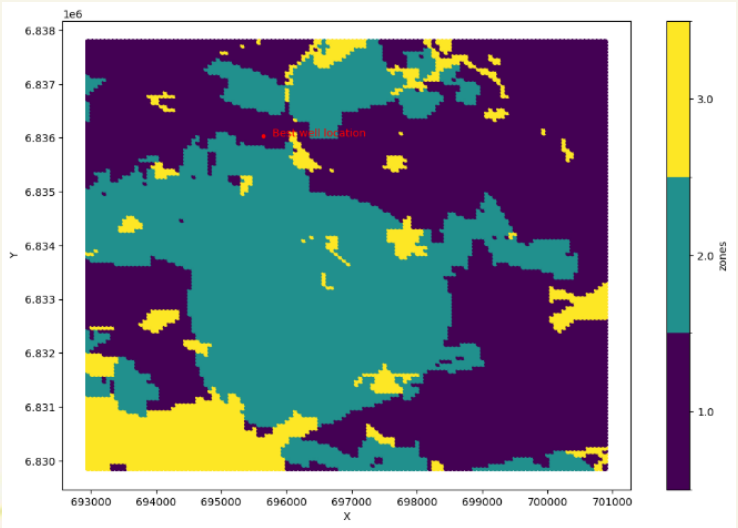
Distance to CO2 source



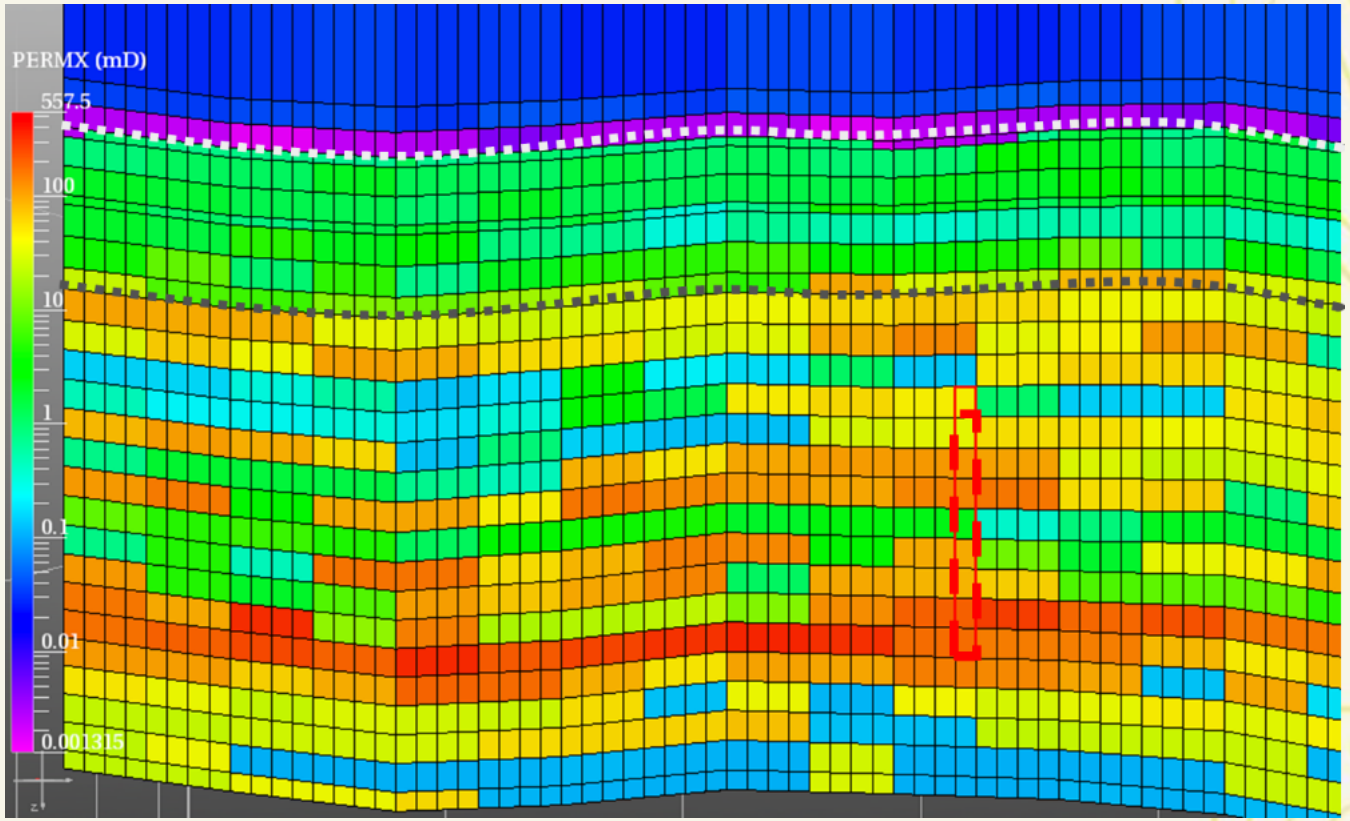
WP3 - Simulation

Well location optimization





- 4 potential location sites are proposed
- 1 is preferred site => quality / discussions with WP4



Presentation organisation

Strategies => Which scenario to pick ?

Paris Basin

1) Pilot fast-track development at minimal cost to prove technical feasibility → Truck transport / Pipeline transport

2) Prepare/develop pilot for commercial development (attract project developers) → No transport

3) Minimise project footprint on local communities → No transport

4) Foster local economy, nearby communities' development → Pipeline transport

5) Showcase CCS solutions and associated advantages (build world-class CCS demonstrator) → Truck & Train transport / Pipeline transport

Strategies => Which scenario to pick ?

Scenario 1: Pilot fast-track development at minimal cost to prove technical feasibility

STRATEGIES	DECISIONS										
	CO2 Source	*CO2 Transport solution*	*Continuity of supply*	*Total CO2 quantity to be injected*	*Injection plant / surface facilities*	*Power supply*	*Well design*	*Monitoring strategy*	*next phase Funding*	*Project duration*	*Project budget*
Pilot fast-track development at minimal cost to prove technical feasibility	Borealis	~~Onsite (injection well within CO2 plant)~~	Continuous	Research permit (< 100 k tons)	No facilities i.e. manifold hooked up to injection well	power grid	Vertical, basic completion	4D seismic	UE	5 years	< 10 M€
	Total Grandpuits	~~Road (Truck)~~	Intermittent	Min. to obtain meaningful results (~30 k tons)	Temporary surface facilities with reduced footprint	solar / wind	Deviated, enhance completion design	DAS	State initiative	Minimum to obtain results (30ktons) i.e. 3 years / check Quest	< 20 M€
	Waste incinerators, large CO2 emitters nearby Paris (as identified in Strategy CCUS)	Railway (Train)		Amount to achieve commercial scale ("autorisation environnementale unique")	Permanent injection facility	geothermal		New surveillance wells	consortium public/private	Commercial design life e.g. 30 years	Commercial scale (~100 M$)
	Distant CO2 emitters (e.g. steel industry in Northern France)	Pipeline						legacy O&G wells	Private equity		
	CO2 market										

Optimal well location based upon surface and subsurface constraints

Preliminary site selection with technical parameters for Pilot Development

Zone 1:

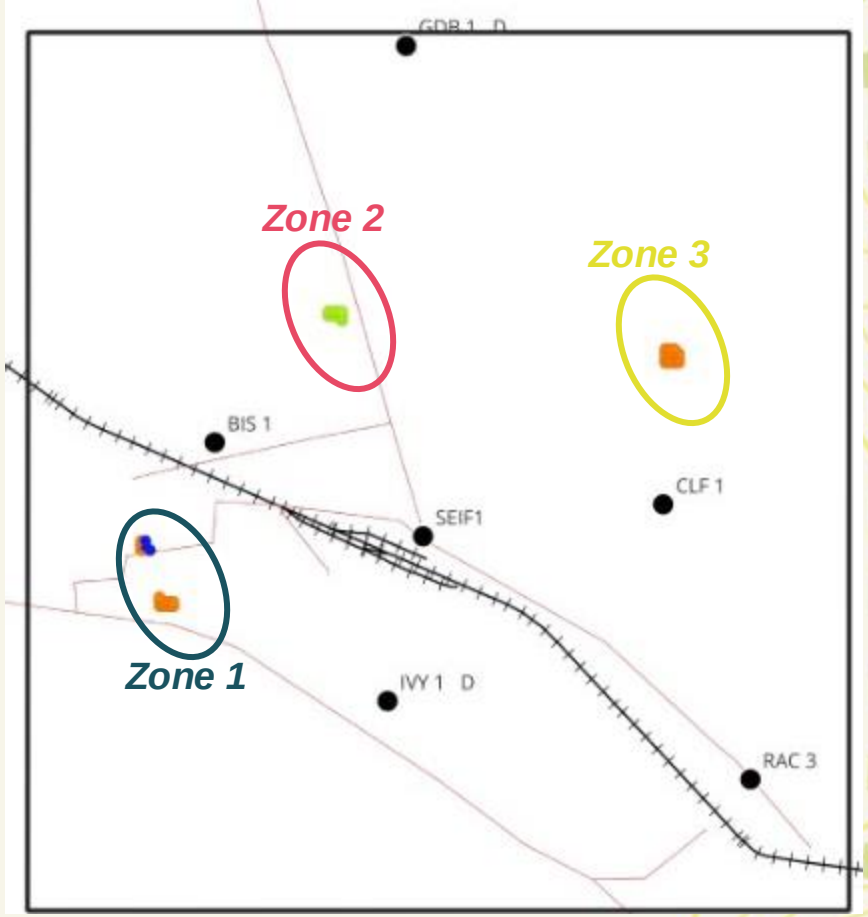
- ***Cost and technical issues to cross railway for carboduc***

Zone 2:

- ***Possibility to develop carboduc following pre-existing pipeline routes***

Zone 3

- ***Possibility to develop carboduc following pre-existing pipeline routes***
- ***Distance to CO_2 source is further compared to Zone 2***

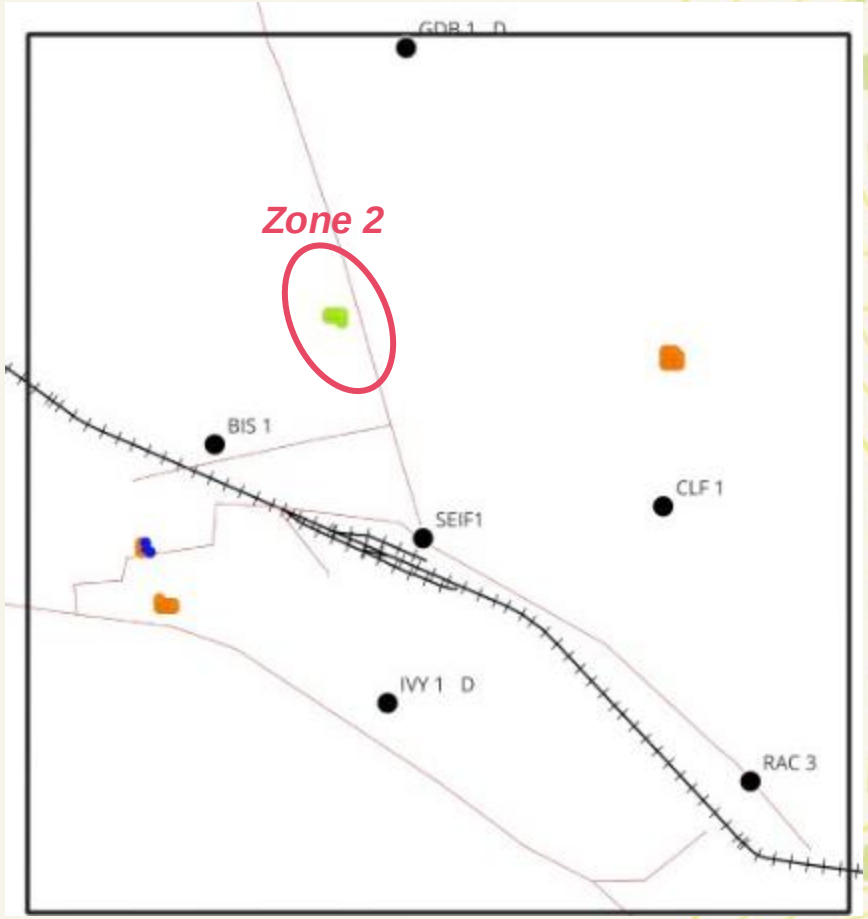


Optimal well location based upon surface and subsurface constraints

Preliminary site selection with technical parameters for Pilot Development

Zone 2:

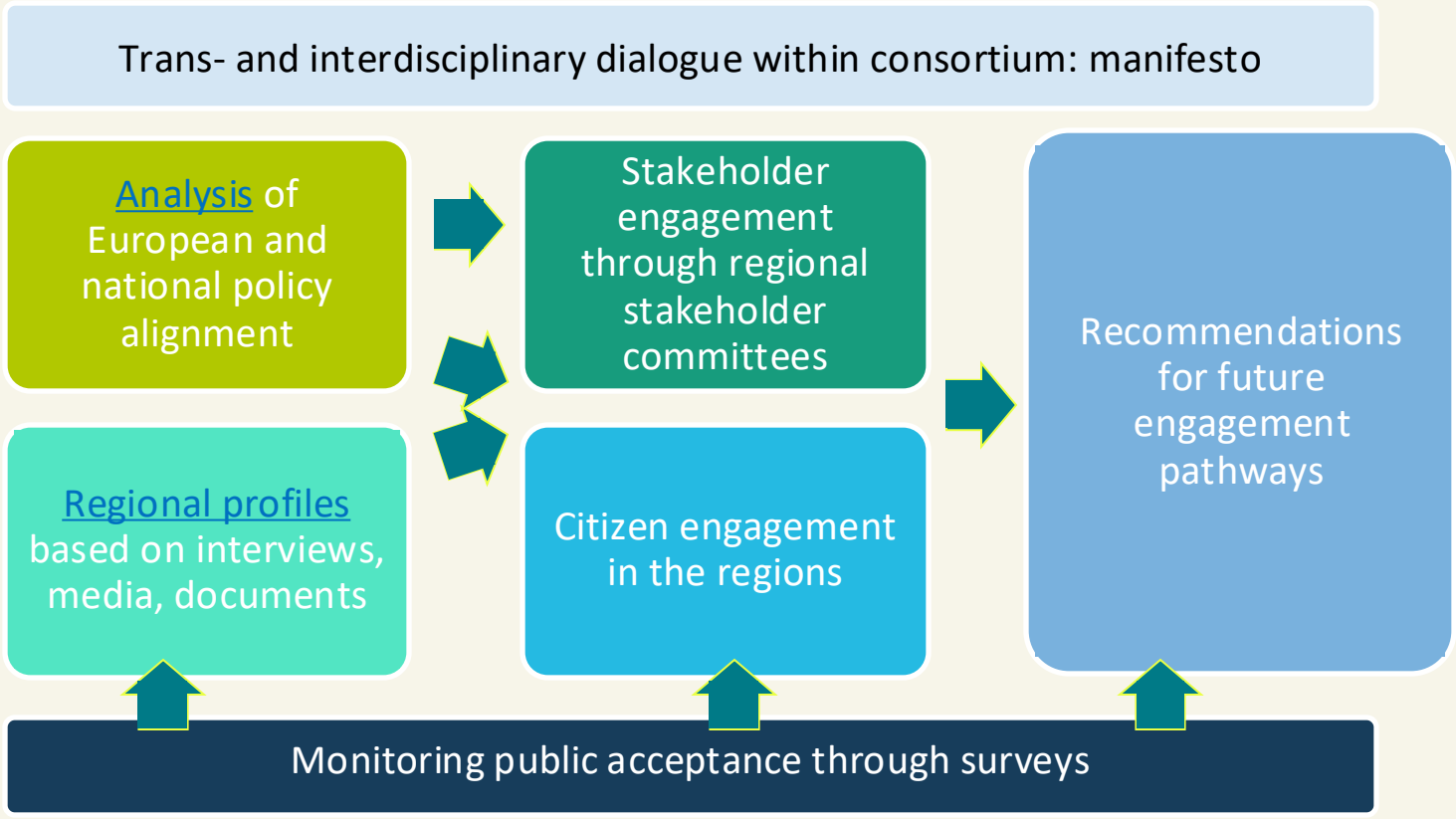
- ***Minimum distance to CO_2 source***
- ***Carboduc would mostly follow existing pipeline routes***
- ***In order to reduce impact on agricultural crops, decision to propose deviated well***
- ***Well head located near to road***
- ***Well TD at the optimized well location proposed by WP3***



Presentation organisation

One objective => Engagement with stakeholders and population

General methodology applied all along the PilotSTRATEGY Project



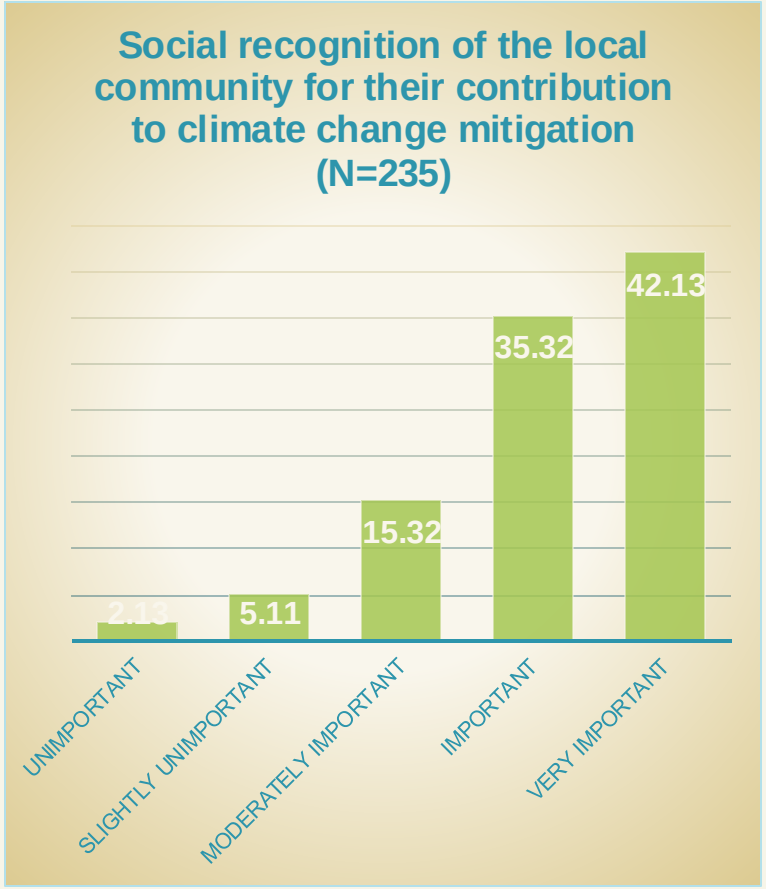
France specificity:

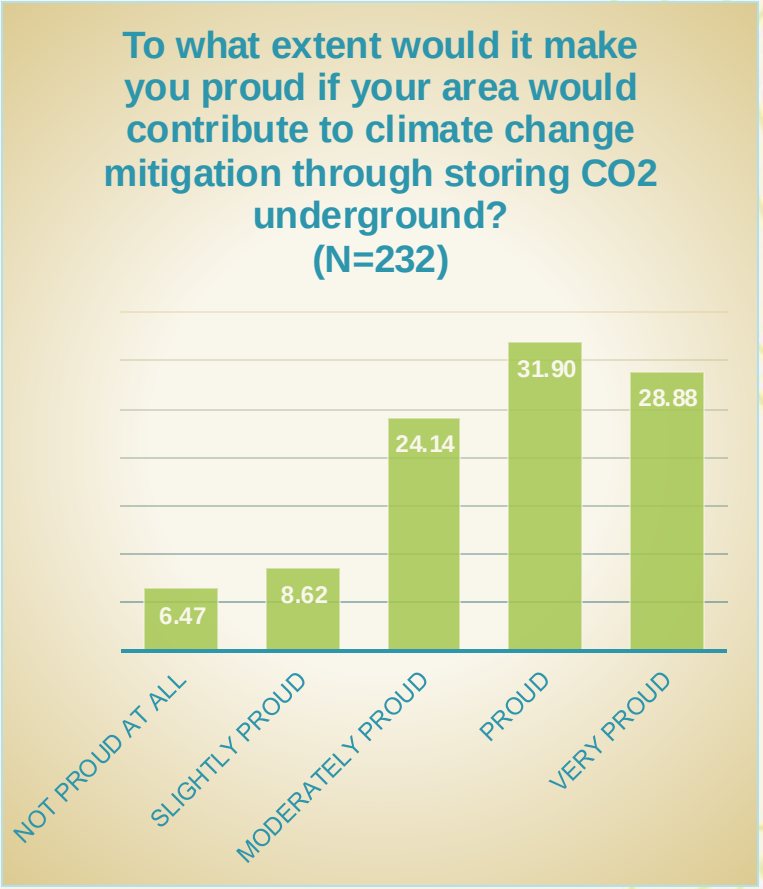
- Interdisciplinary cooperation
- Working relationship with stakeholders and the population
- Adaptation through project life and territory evolution

Survey of the local population => Results from 2022

Main conclusions from survey:

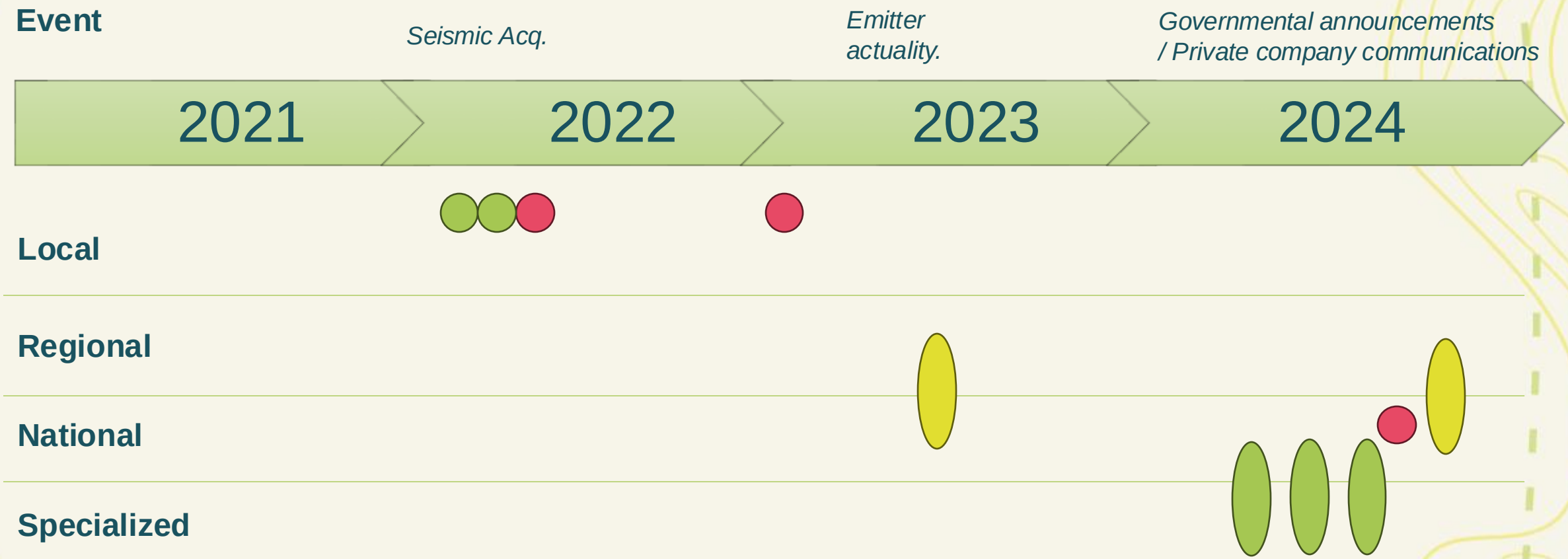
- **Global acceptance**
  - **32% => Acceptable**
  - **41% => Rather acceptable**
- **Two key reactions**
  - **Social recognition**
  - **Pride**
- **Role of the project integration in the territory for acceptance:**
  - **CO_2 source is local from historical fertilizer plant**
  - **Negative feedbacks if CO_2 comes from another place**





Follow survey in 2025 => End of the project

Survey of local / regional / national Press or Communications



Related to PilotSTRATEGY project

WP6 - Social Acceptance

Citizen and stakeholder engagement

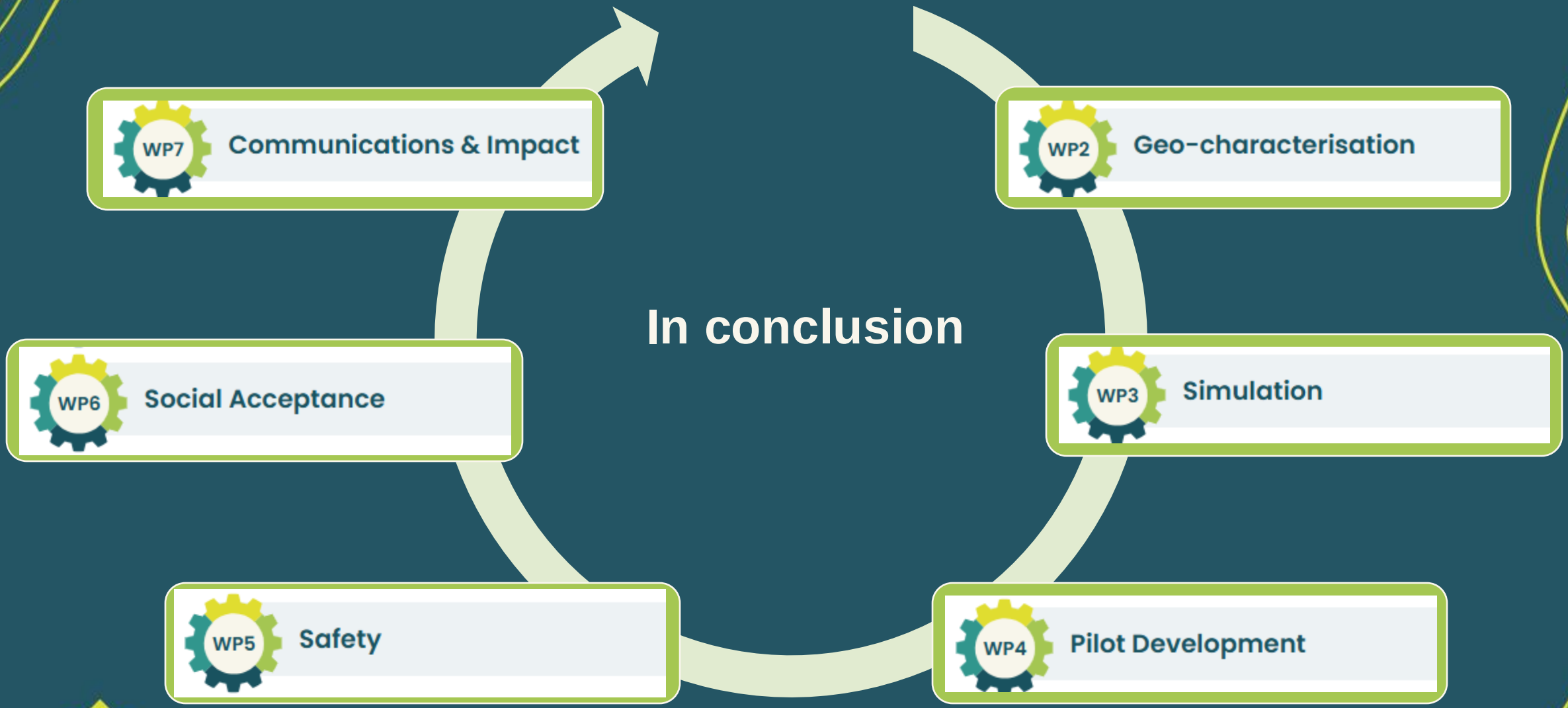
Public **Open Doors**
- 1 per year (3 to date)
- Adapted to public, current research status, feedback from Stakeholders Committee

Regional Stakeholder Committee meetings (Groupe de réflexion '*Adaptations & Territoire*')
- 1 per year (next one 18/11)
- Specific discussion of technical subjects, concerns and perceptions

Main features from social engagement work:

- **Adaptation** by each player (Science team / stakeholders / population) – Important **reciprocity**
- **Interdisciplinary** work – many exchanges between scientists to communicate the research relevant to stakeholder inquiries
- **Social recognition** and **pride** are two key reactions to follow up

In conclusion



Project time line

- Seismic data acquisition
- Sedimentological description and petrophysical measurements
- Historical data enhancement

Subsurface data acquisition

- Develop numerical model which attempts to represent subsurface reservoir complex

Static modelling of the reservoir complex

- Predict reservoir behaviour during CO_2 injection, CO_2 plume evolution , pressures, etc…

Dynamic simulation with CO_2 injection

- Optimised well location
- Scenarios evaluation
- Environmental and economic assessment

Pilot conceptualisation

Risk assessment

May 2021 | May 2023 | May 2024 | May 2025 | May 2026

Discussion and exchanges with stakeholders

Onshore CO_2 Storage in the Paris Basin: An Overview of Geological, Technical, and Social Studies

Autumn webinar, 7th November 2024

The PilotSTRATEGY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022664