PilotSTRATEGY project –
CO_2 Geological Storage Pilots in Strategic Territories

Final Event

Isaline Gravaud (BRGM) – Project coordinator

Brussels, April 21st, 2026

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

Agenda

Tuesday 21 April	Consejo Superior De Investigaciones Cientificas (CSIC) / Office of the Spanish Research Council	09:00 - 09:15	**Welcome coffee**	
		09:15 - 09:30	**Welcome - General project overview**	Isaline Gravaud (BRGM)
		09:30 - 11:30 **Morning session 1**	**Project impact and way forward in PilotSTRATEGY regions** **(**Ebro Basin, Lusitanian Basin, Paris Basin, West Macedonia, Upper Silesia**)**	**Chair:** Richard Stevenson (SCCS/UEDIN) **Speakers:** Aurélien Bordenave (BRGM) Paula Canteli (IGME) Julio Carneiro (UEVORA) Pavlos Tyrologou (CERTH) Krzysztof Stańczyk (GIG)
		11:30 - 11:45	**Break**	
		11:45 - 12:45 **Morning session 2**	**Perspectives from other regions & projects** Prinos CO2 Storage Project, Greece ANRAV-CCUS, Bulgaria	**Chair:** Pavlos Tyrologou (CERTH) **Speakers:** Pantelis Vogiatzis, Prinos CO2 Storage Project, EnEarth, Greece Konstantin Bojinov, ANRAV-CCUS, Heidelberg Materials, Bulgaria
		12:45 - 13:30	**Lunch**	
	European Parliament	**14:30 - 16:30** **Afternoon session**	**PilotSTRATEGY session in European Parliament** - Welcome by host MEP Paulo Cunha - PilotSTRATEGY outcomes and impacts - Panel session: *The way forward for CCS in Southern and Eastern Europe* - Closing remarks	**Host:** Paulo Cunha MEP **Project speakers**: Isaline Gravaud (BRGM) Paula Canteli (IGME-CSIC) Júlio Carneiro (University of Évora) **Panel speakers:** Chair: Aymeric Amand, ZEP Toby Lockwood, Clean Air Task Force Elisabeth Dütschke, Fraunhofer ISI Zsuzsanna Szeles, European Commission/DG ENER Koen Coppenholle, Cement Europe

PilotSTRATEGY

General framing

- **Support development** of carbon capture and storage (CCS) in **Southern and Eastern Europe**
- Investigate **deep saline aquifers:** large capacity for storing CO_2.
- **Preparing the ground** for full and active development into operational storage sites.

The five-year PilotSTRATEGY project, which commenced in 2021, has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement nº 101022664.

PilotSTRATEGY

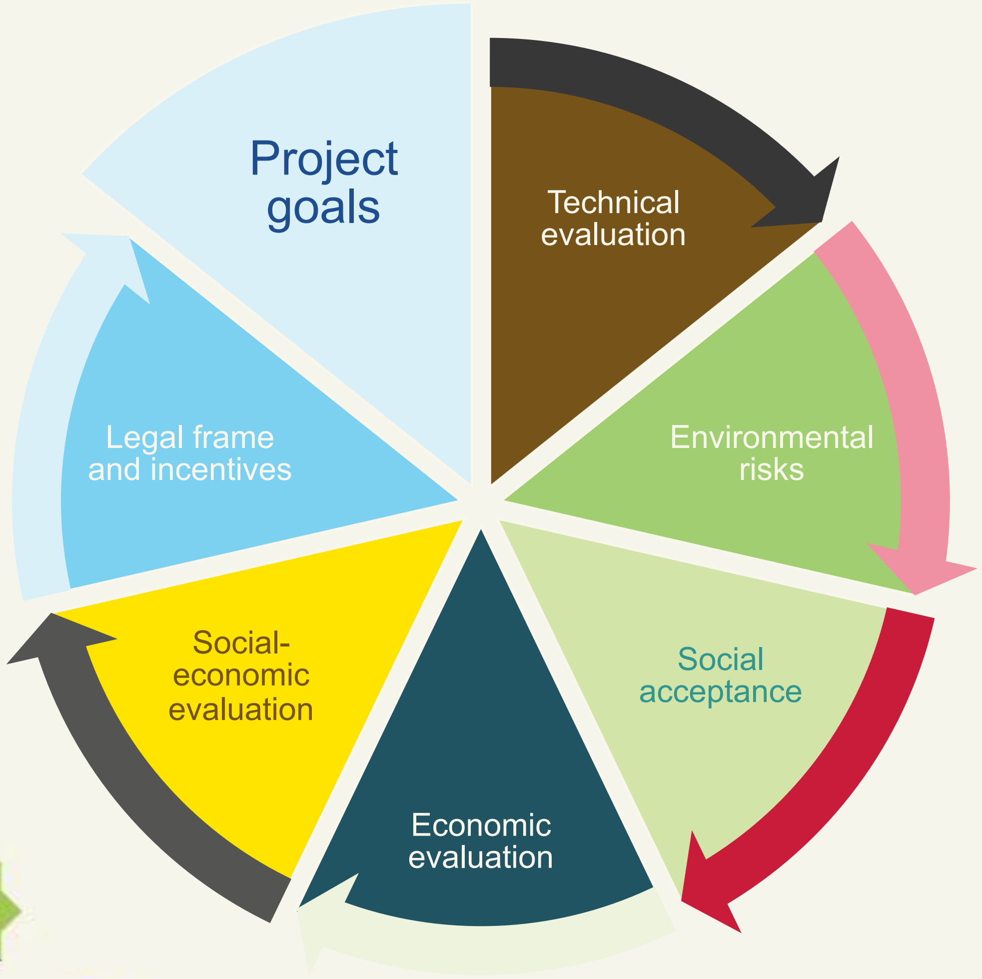
PilotSTRATEGY (H2020 RIA)

- 5 regions studied
- 16 partners (+ 3 FR third parties) from 7 countries
- 5 years from May 2021 to April 2026

Objectives

- **Increasing the maturity and readiness** assessment of aquifer storage resources in five European promising regions.
- **Detailed study** for CO_2 geological storage pilot sites in selected areas of interest.
- Identifying and engaging relevant **end users and societal stakeholders** for the implementation of new CO_2 storage pilots.
- Propose **development plans** for the CO_2 storage pilots.

Multi-criteria approach



- **Detailed study of deep saline aquifers** for CO_2 geological **storage pilot sites**
- Study of **social acceptance** through **stakeholders and citizens engagement**
- **Class IV Economic evaluation** of **CCS concept** for storage sites in FR, PT and ES
- **Development proposal** for the 5 pilots (**pre-investment** proposal for the 3 pilots in FR, PT and ES)

Project workflow

May 2021

Geo-characterisation and geological model

- Geophysical surveys or data reprocessing
- Sedimentological description
- Petrophysical measurements
- Geomechanical and geochemical assessment

Static modelling of the reservoir complex

- 3D geological model of storage complex: reservoir, caprock, structural elements
- Porosity and permeability distributions

Dynamic simulation with CO_2 injection

- Optimized well location and injection strategy
- Integrity of near wellbore, caprock and fault/fractures
- CO_2 fate on the long term

Risk assessment

- Safety and performance of the storage site
- Risk assessment: leakage (legacy wells, faults, caprock integrity), plume migration, seismicity

Pilot concept and development plans

- Pilot concept
- Well design, MMV plan, capture-transport-storage facilities
- Environmental impact assessment
- Economic evaluation
- Investment proposal

April 2026

Social acceptance and community engagement

- Policy context
- Community profiles in the regions
- Stakeholder engagement
- Citizen engagement

PilotSTRATEGY

Acknowledgements

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PilotSTRATEGY

Thank you for listening

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PilotSTRATEGY

PARIS BASIN REGION, FRANCE

Short technical overview & way forward

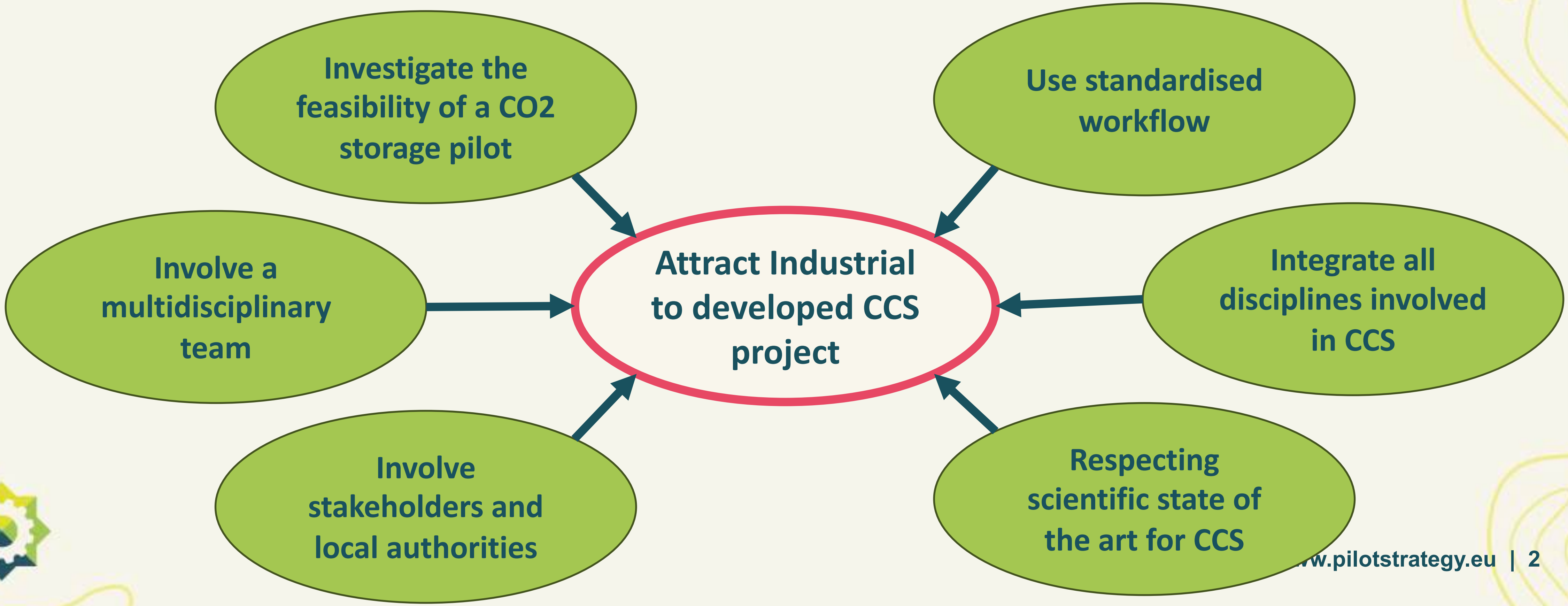
Final Event – 21st & 22nd April 2026 – Brussel Belgium

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 – French Region

What was the specific objectives for the French team ?

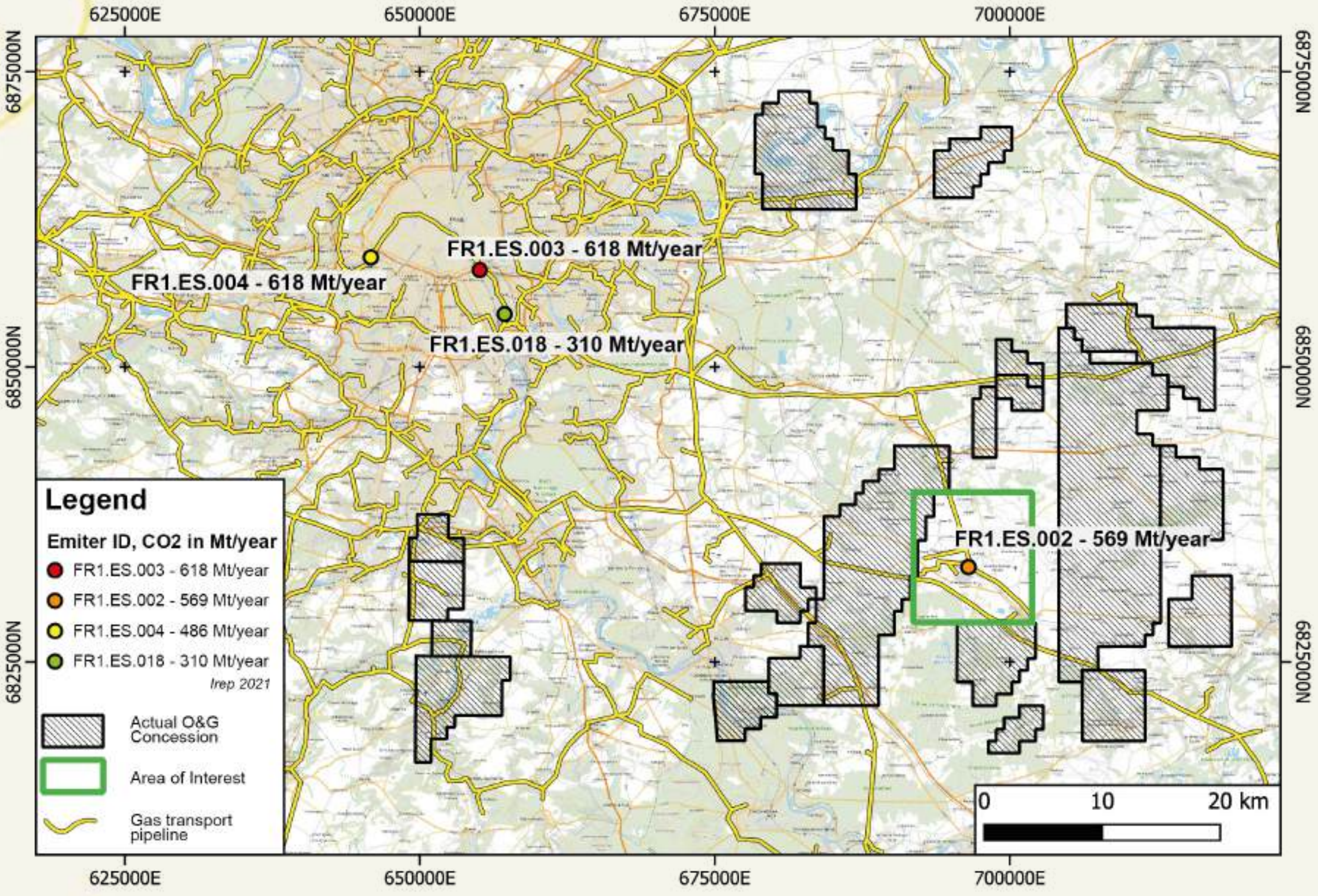


Presentation organisation

1. Site presentation
2. Storage site specificities
3. Concept of the Pilot
4. Economical assessment
5. Stakeholder engagement
6. Project dissemination

PilotSTRATEGY – French Region

Site presentation – The Nangis Area



Location map of the Area of Interest with principal emitters (>300kt$_{CO2}$)

Lat-Nitrogen Fertilizer plant

- **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**
  - Strongly prospected area in the past (O&G)
  - New seismic data (3D)
- **Preliminary CO_2 storage capacity estimation**
  - Sufficient estimation for a pilot test

Site presentation – Historical dataset and New Data

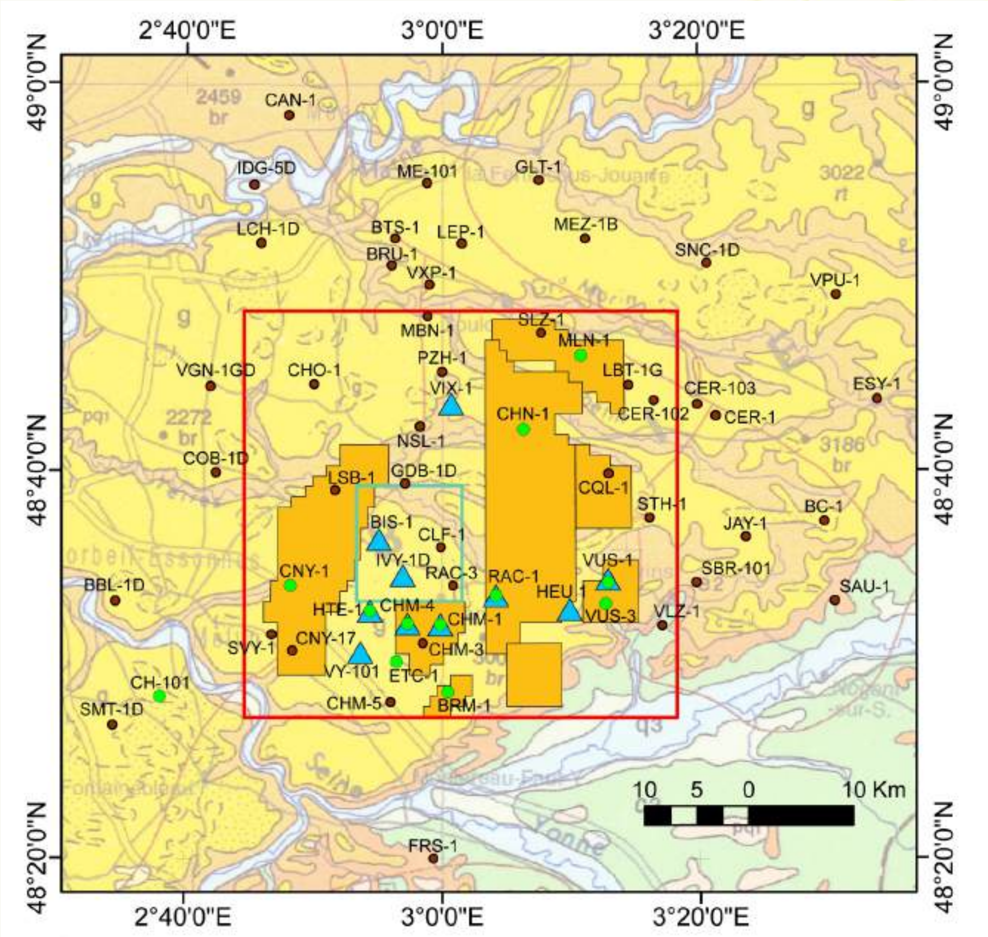
Well log data:

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

Cores:

- 477 meters divided onto 12 wells
- Dalle Nacrée / Comblanchien / top Oolithe Blanche Fmt.
- High frequency sequence stratigraphy study

- **Thin section**
  - Mostly samples from topmost reservoir
  - 240 thin-sections divided onto 12 wells
- **Plug**
  - Mostly from topmost reservoir interval
  - K/Phi measures – 470 plugs sur X forages



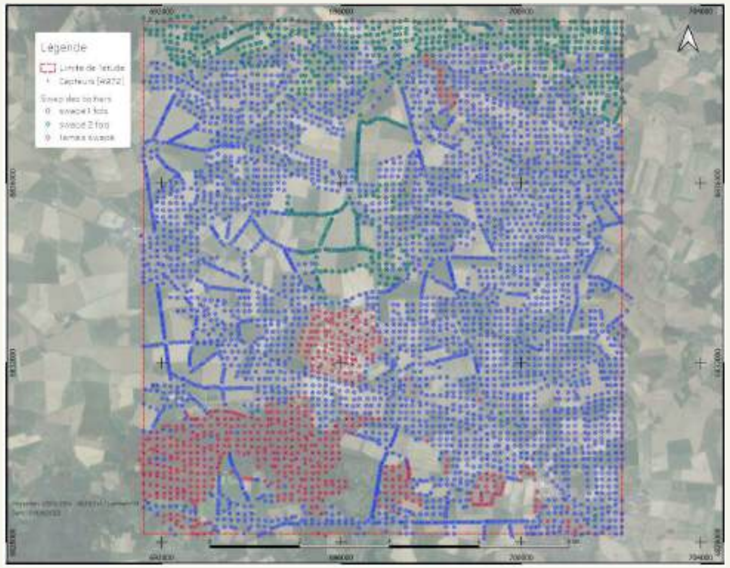
Data distribution in the Area of Interest (red square)

=> New 3D seismic data

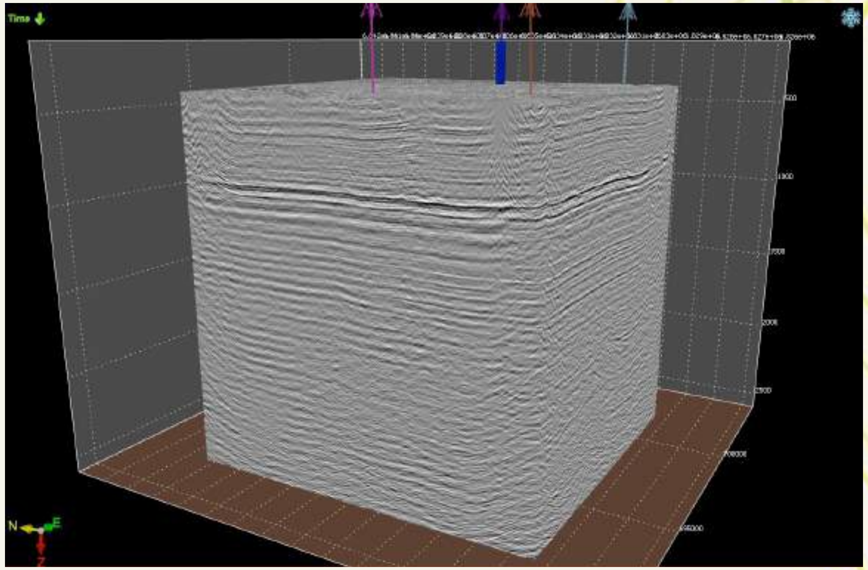
smart seismic solutions

Site presentation - Newly acquired 3D seismic data

Vibrateur Mertz 27t during acquisition



Sensors map location



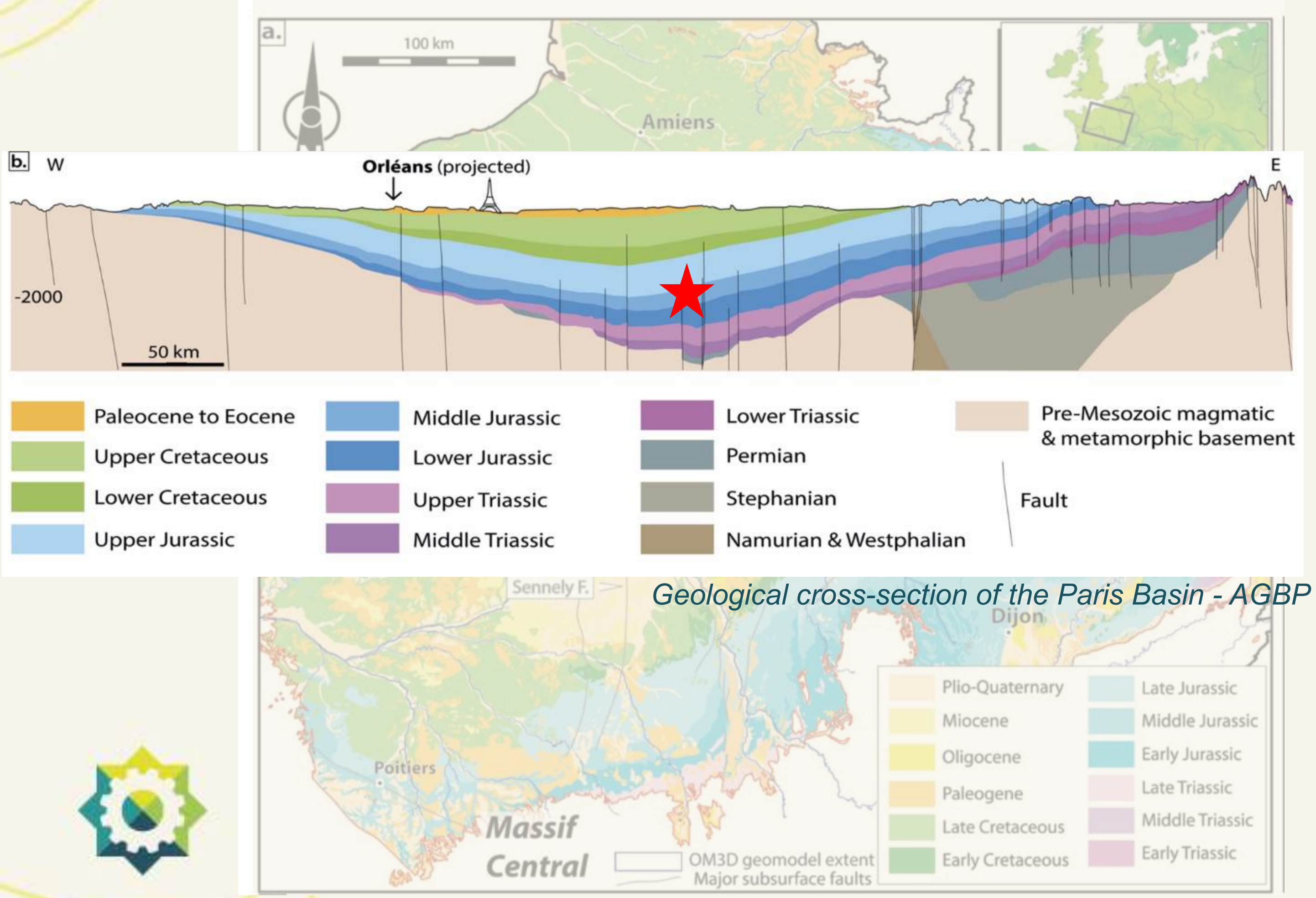
Processed 3D seismic data

- **Involvement of the public and public authorities**
  - Meetings with various partners (Local, regional, governmental authorities, Chamber of Agriculture)
  - Public meetings with scientific presentation and showcase
  - Specific test onto old drains spread in the area

PilotSTRATEGY – French Region

Site presentation – The Paris Basin

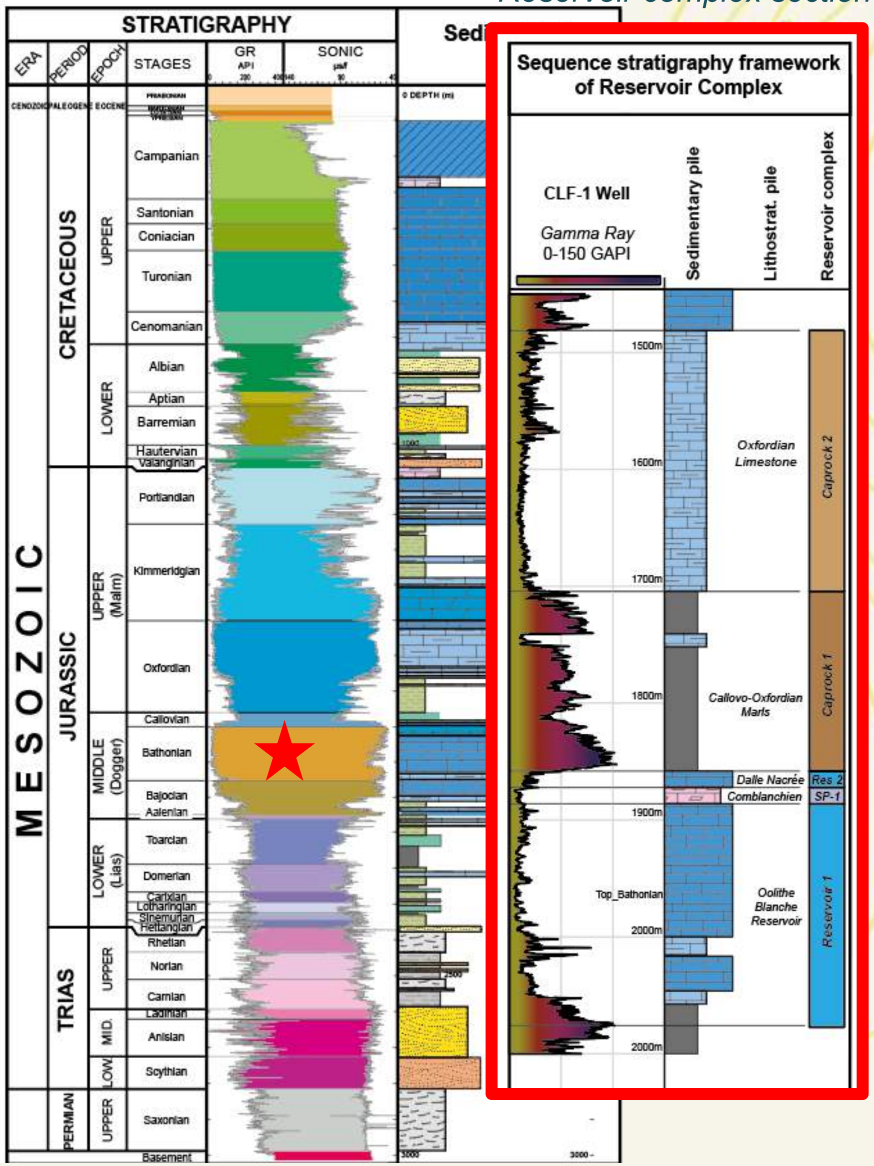
The Dogger Reservoir Complex



Geological cross-section of the Paris Basin - AGBP

Geological map of the Paris Basin - BRGM

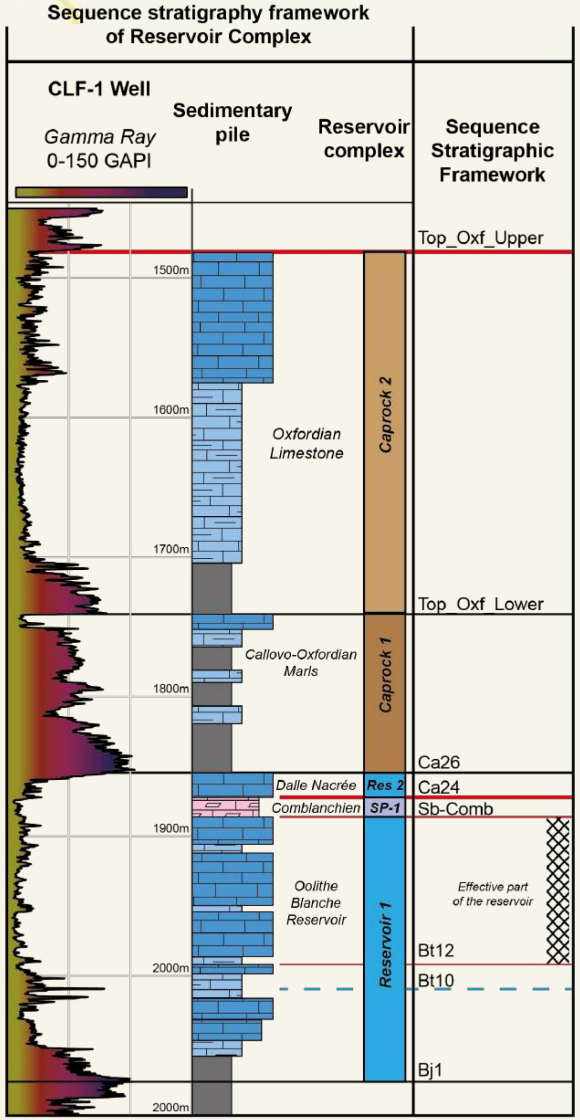
Reservoir complex section



Geological section of the Paris Basin - AGBP

PilotSTRATEGY – French Region

Storage site – Dogger Reservoir Complex



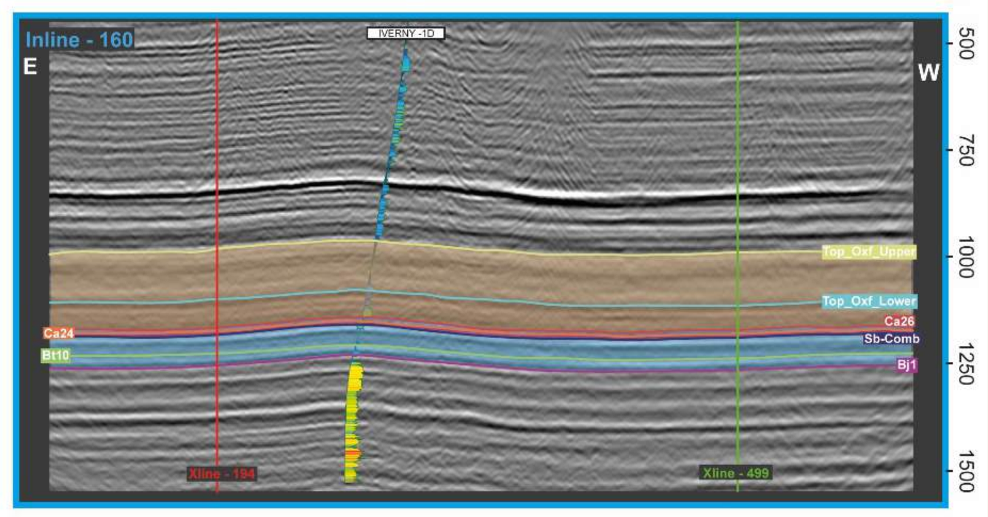
Reservoir complex geological section

Reservoir :

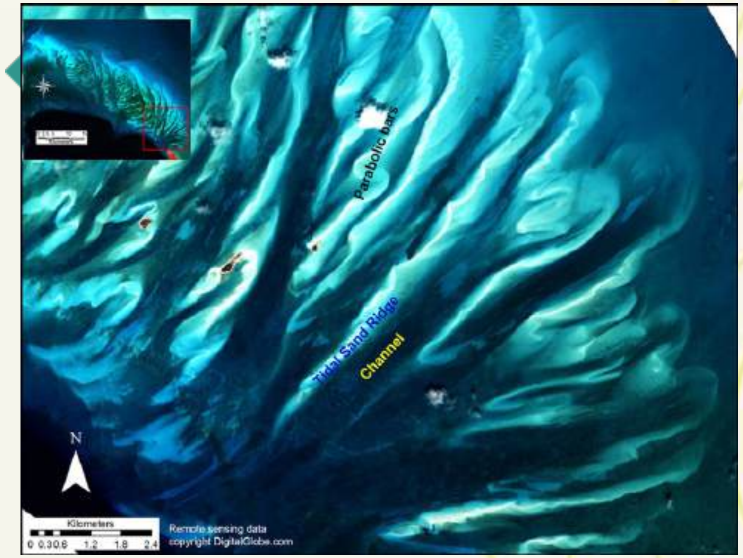
- Oolitic carbonate reservoir
- Depth : 1680 to 1767m SSTVD
- Thickness : 160 – 240m
- Temp. : 60°C / Pressure : 185 bar

Caprock :

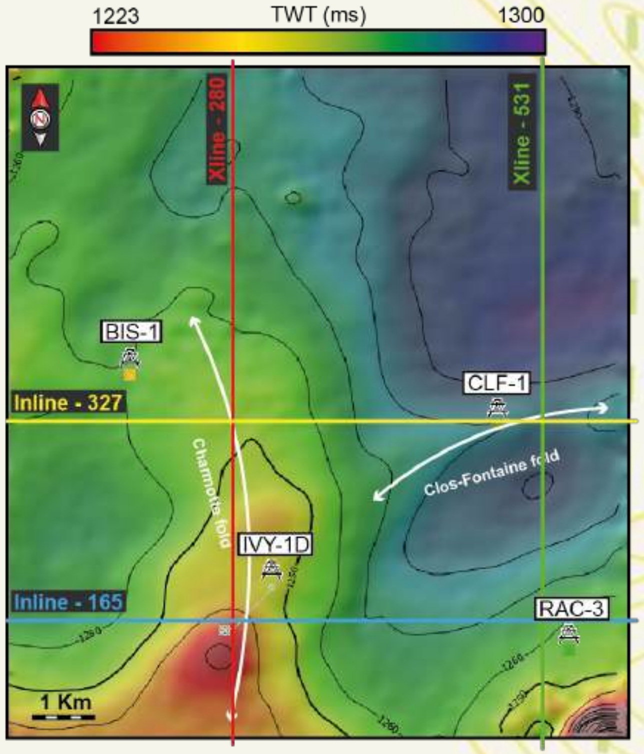
- Caprock 1 – 120m thick marly interval
- Caprock 2 – 250m thick tight carbonate



Interpreted seismic line (Inline – 165)



Bahamas oolitic bank

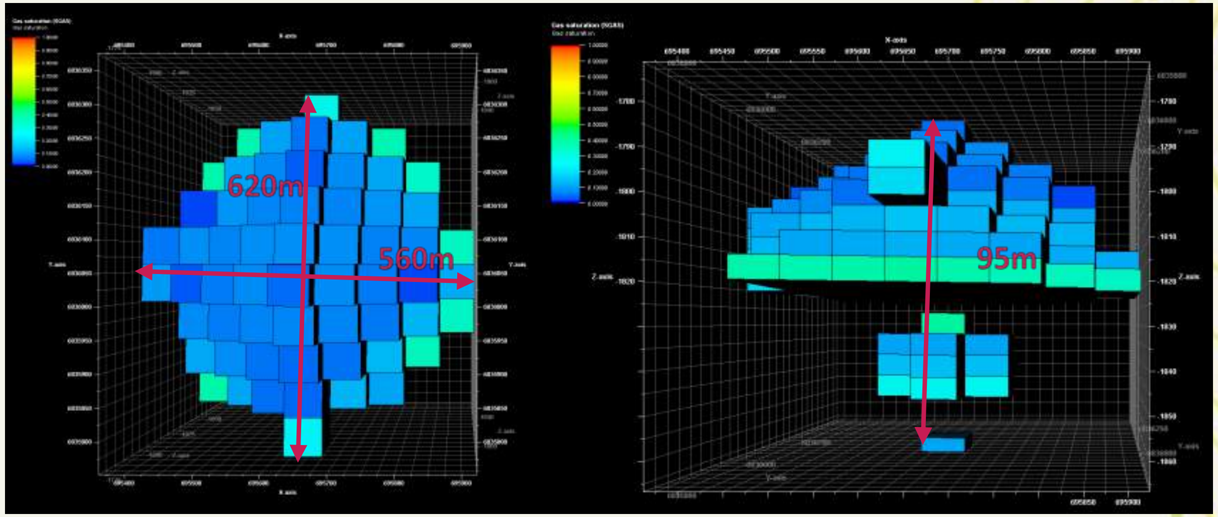


Depth map of Reservoir top – Ca26

PilotSTRATEGY – French Region

Storage site – Complex modelling for injection assessment

Pilot case – CO_2 plume extension after 10 years



Two specific scenarios modelled :

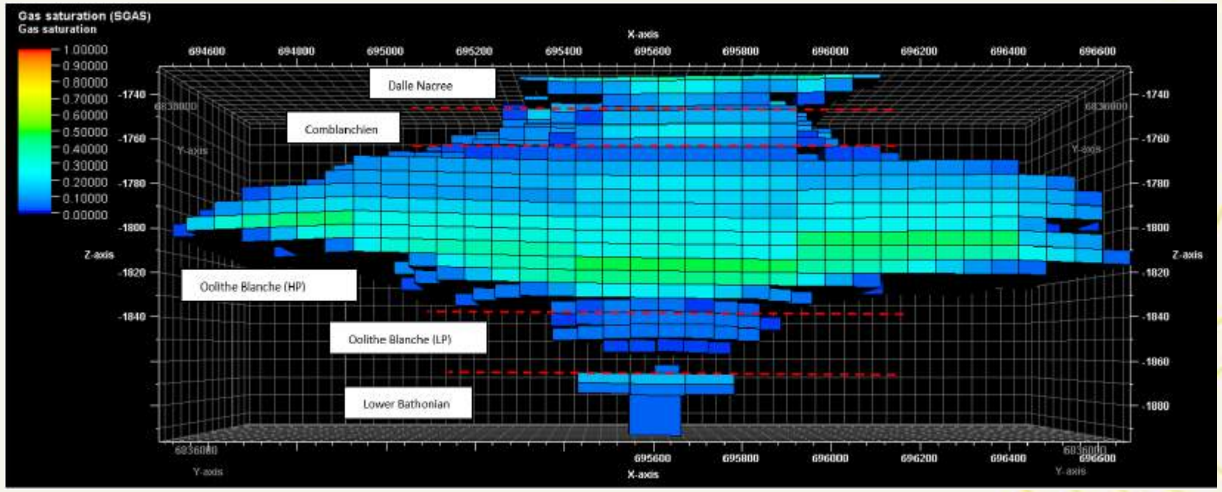
- Pilot case => 100kt - 4months (rate = 300kt/year)
- Commercial case => 300kt/year – 30years

Pilot case after 1 year :

Plume extension : (xyz) **560m - 620m - 95m**
Overpressure >0.2 bar : (xyz) **4470m - 440m - 462m**
CO_2 trapping: **Dissolved CO_2 / Structural trap**

Commercial case after 1000 year :

Commercial case – CO_2 plume extension after 1000 years



Plume extension : (xyz) **3661m - 4870m - 132m,**
Overpressure* >1 bar : (xyz) **2429m - 2729m - 140m**
CO_2 trapping: **Dissolved CO2 / Residual / Structural**

**end of the injection – pression dissipates ~20 years*

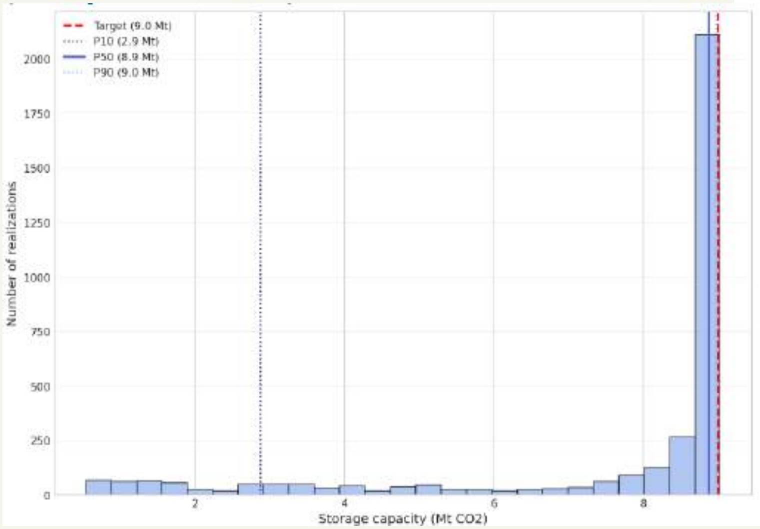
The mineral trapping contribution has not been quantified in these results

PilotSTRATEGY – French Region

Storage site – Risk assesment

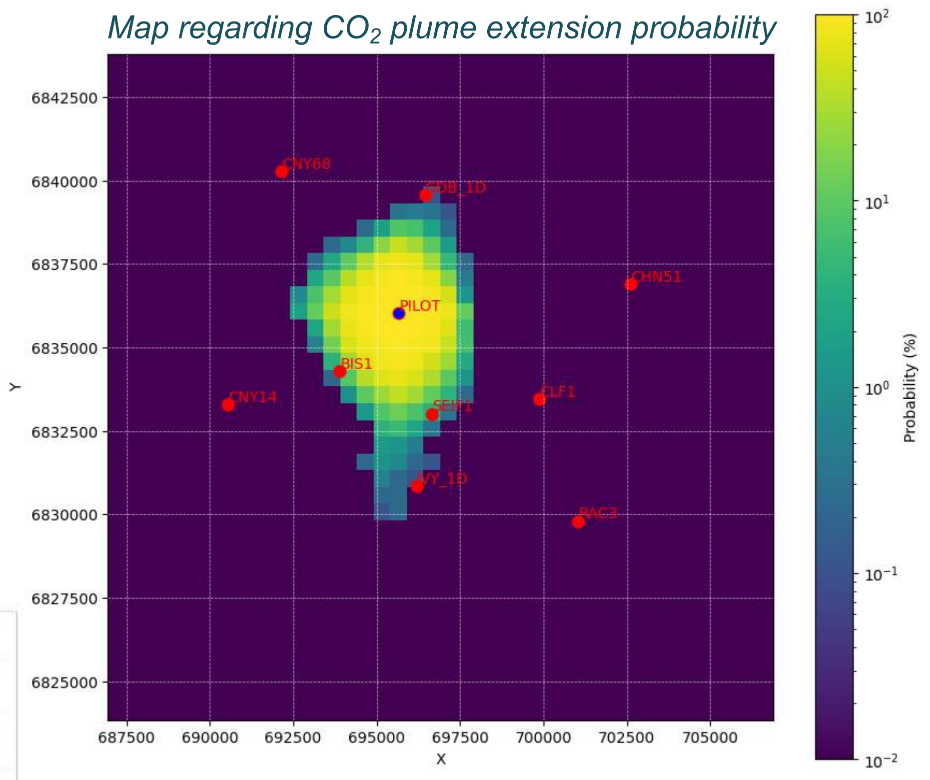
Ris assessment undertake onto two scenarios (Pilot / Commercial):

- **Risk identification** and **assessment**
- **Quantitative** analyses or **Expert based analyses**
- Quantitative : **3000 simulations onto commercial case** / 2016 simulation for Pilot case
- **Pilot Case => No major risk identified** => ***Let's Go***
- **Commercial case => Possible risk regarding legacy well ?**
- **Storage capacity :**
  - **P10 : 2.9 $Mtco_2$**
  - **P50 : 8.9 $Mtco_2$**
  - **P90 : 9.0 $Mtco_2$**



Risk assesment regarding storage capacity

Risk category	Quantitative analysis
Safety risks	
Delays and costs	NO
Politics / Legal	NO
« Social »	NO



PilotSTRATEGY – French Region

Concept of the Pilot – Proposed MMV

MMV plan based on actual reglemetation and potential commercial development :

legend
- Periodic monitoring
- Continuous monitoring

Surface MMV:
- Soil monitoring (gas/pH/salinity)
- Tilt meter
- Passive seismic fiber optics
- INSAR
- Superficial aquifer monitoring

Baseline + final + post-injection

Well head MMV:
- CO_2 flowrate
- Pressure
- Annular pressure
- Isotopes

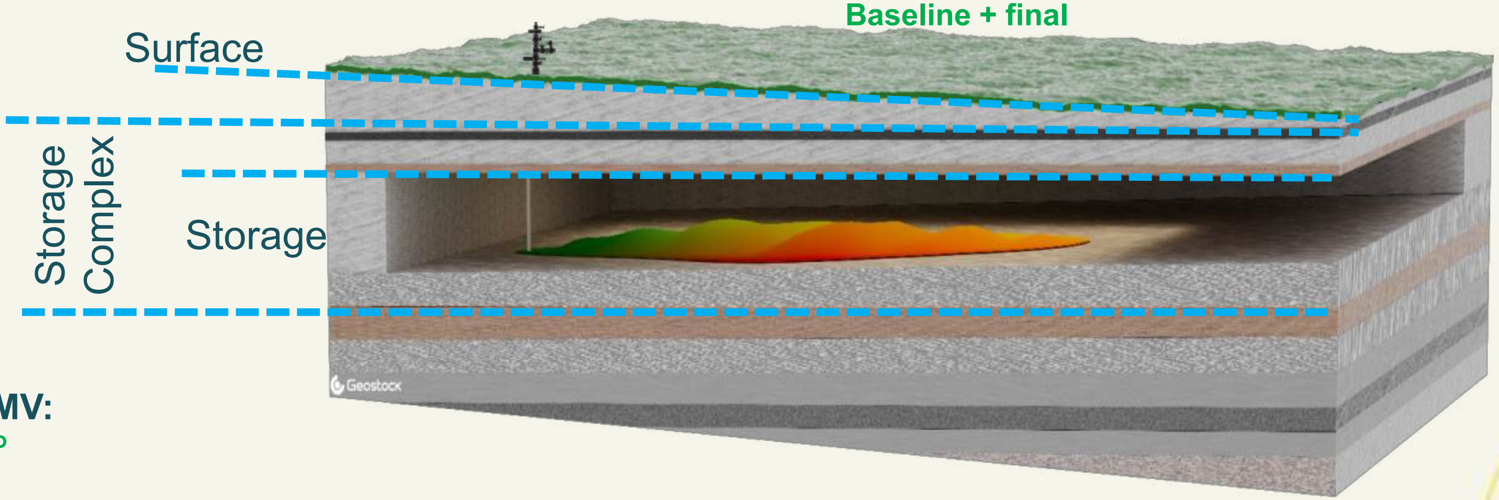
Baseline + final

In well MMV:
- CBL/USIT
- Permanent downhole P&T gauges
- Multi-component fiber optic (DAS/DTS/DSS)
- Density/saturation cased-hole logging
- Caliper

Baseline + final

Storage Complex MMV:
- Water quality sampling

Baseline + final + post-injection
- Microseismics

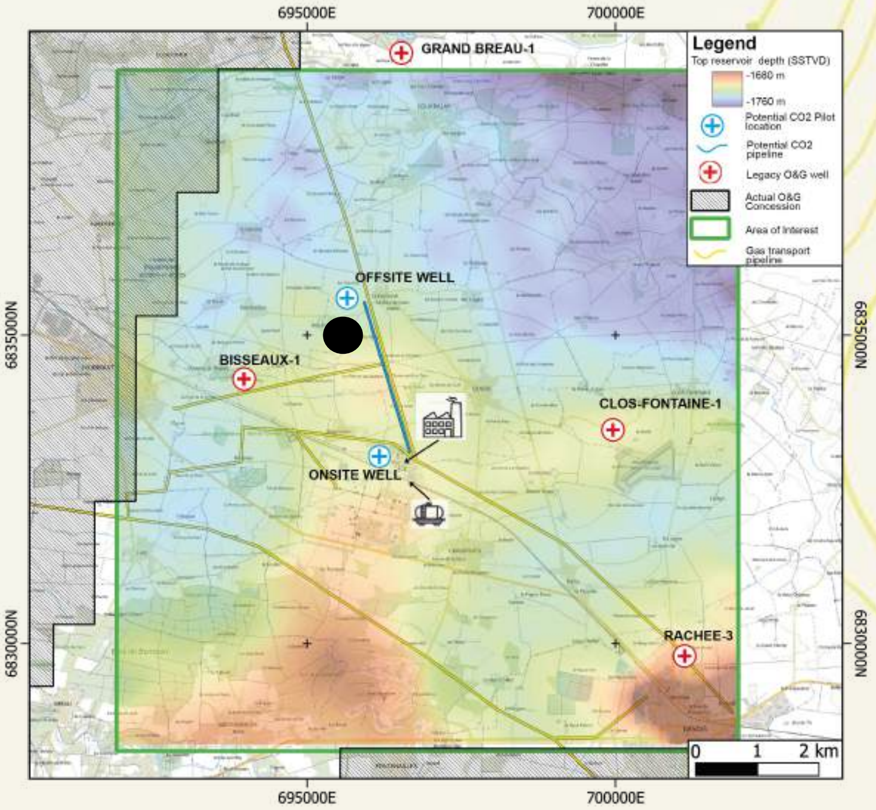


Storage MMV:
- DAS VSP
- Spotlight

Baseline + 1 repeat/month + post-injection

PilotSTRATEGY – French Region

Concept of the Pilot – Selected scenario



Location of potential sources and wellsites

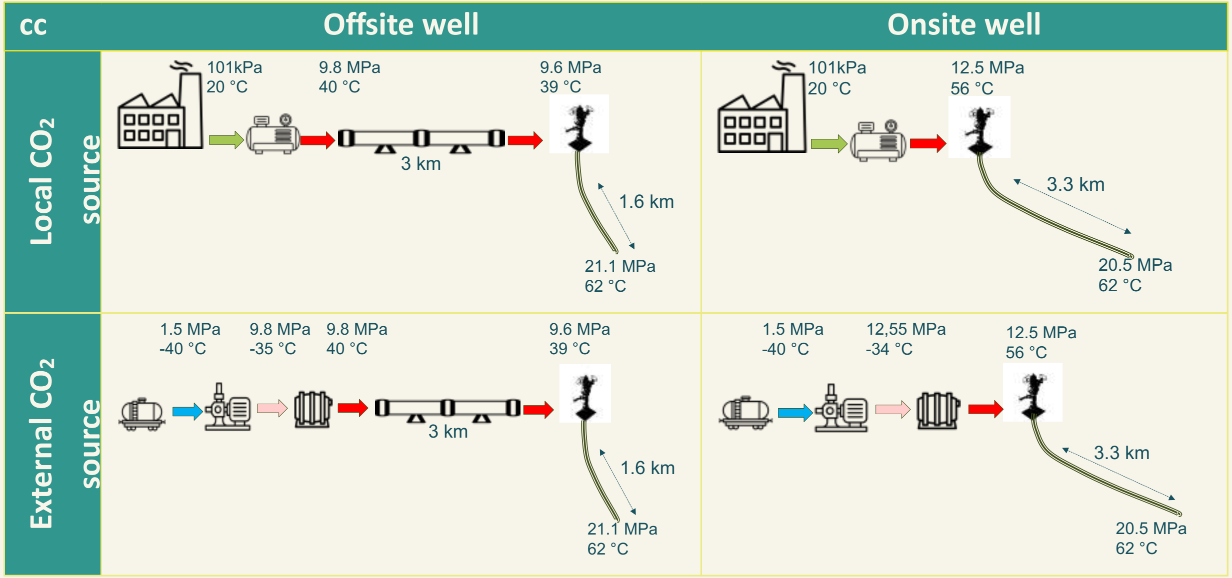
__Objective of the selected scenario :__

- Test **technical feasibility**, **safety**, and **environmental** compliance for a hypothetic **large-scale CCS** deployment.
- **CO_2 pilot** injection is **limited to 100 kt** according to article R229-61 of the **French environmental code**.
- Require **approval from the French regulatory authorities** under the Environmental and Mining codes **through an Exploration permit (PER).**

Four potential scenario regarding two parameters :

=> Source of the CO_2

=> Well placement scenarios



Representation of the 4 different potential scenarios for the Pilot case

PilotSTRATEGY – French Region

Economical assesment

Pilot case cost estimation regarding 4 scenarios

A probabilistic class IV cost assessment :

Main Drivers for **Pilot scale project:**

- **Local CO_2** *vs.* **External CO_2**
- **Onsite well** *vs* **offsite well**
- **Storage** VS **Complex storage MMV**

Main drivers for **Commercial scale project** :

- **Investment regarding MMV plan** (deep monitoring well + one well in the first aquifer above caprock)
- Add on with DAS-VSP and soil & water sampling, Micro-seismic monitoring and INSAR

Scenario	Offsite total cost (M€$_{2025}$)			Onsite total cost (M€$_{2025}$)		
	P10	P50	P90	P10	P50	P90
Local CO_2	64	74	85	67	76	88
External CO_2	41	45	50	45	49	53

Recent evolution of the industrial activity & local stakeholders discussion

=> the onsite well with external CO_2 is an interesting alternative

Investment cost regarding the commercial case

Offsite total cost (M€$_{2025}$)			Onsite total cost (M€$_{2025}$)		
P10	P50	P90	P10	P50	P90
55	59	63	57	61	66

PilotSTRATEGY – French Region

Citizen & Stakeholder engagement

Open Doors meeting – Grandpuits

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 (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
- **Modification of the acceptability** regarding Fertilizer plant evolution

PilotSTRATEGY – French Region

Communication / Dissemination / Impact

Communication / Dissemination :


Interview "Un potentiel de stockage" : c'est quoi ce projet d'enfouissement de CO2 dans le sol de la Seine-et-Marne ?

Coordinateur du projet PilotStrategy, le Bureau de recherches géologiques et minières détaille les études de faisabilité d'un stockage de CO2 dans le sol de la Seine-et-Marne.

Environnement Pollution

Article réservé aux abonnés S'abonner

En Seine-et-Marne, la présence de l'usine LAT Nitrogen (ex-Boréalis), longtemps gros producteur de CO2, est un des critères expliquant que le site de Grandpuits ait été retenu dans le cadre d'un projet de recherche visant à évaluer la possibilité de stockage du dioxyde de carbone dans le sol ©LAT Nitrogen

Communication Regional / National Press

Public conference in Grandpuits

National / European / international scientific congress

Project impact onto the French territory

Industrial impact :

- Interest from Industrial (Emitter and storage company) onto the project
- PER request from C-Questra start-up

Industrial impact :

- Project integrated in the decarbonation strategy for the French territory
- Partners mobilized by Government for storage capacity estimation on the national territory

Research impact :

- Special publication (IJGGC)
- Induced national (PR3DICT, EXPLOR CO2) and European (Investment Atlas) research project

Who is the French Team ?

brgm
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Nicolas Gonthier

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Vermilion Energy
Marine Di Matteo
Aloys Baudesson
Chaker Raddadi
Sophie Palu

arverne group
Guillaume Tarnaud

⇒ Over 35 persons participate to the project

Many thanks to them for their contribution

PilotSTRATEGY

Acknowledgements

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PilotSTRATEGY

Ebro Basin Region, Spain

Project impact and way forward in PilotSTRATEGY regions

Paula Canteli (IGME-CSIC)

21st April 2026, Brussels

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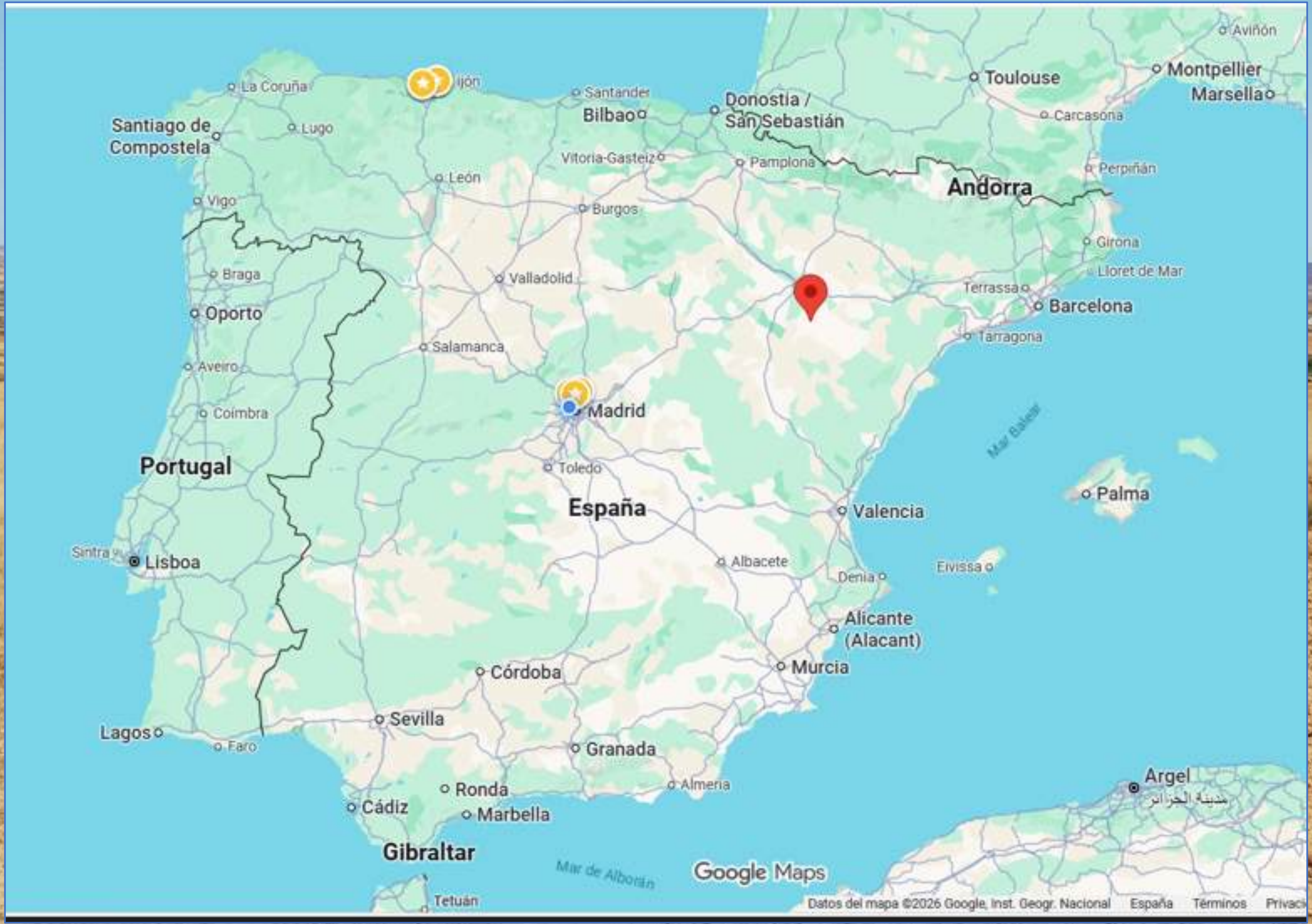


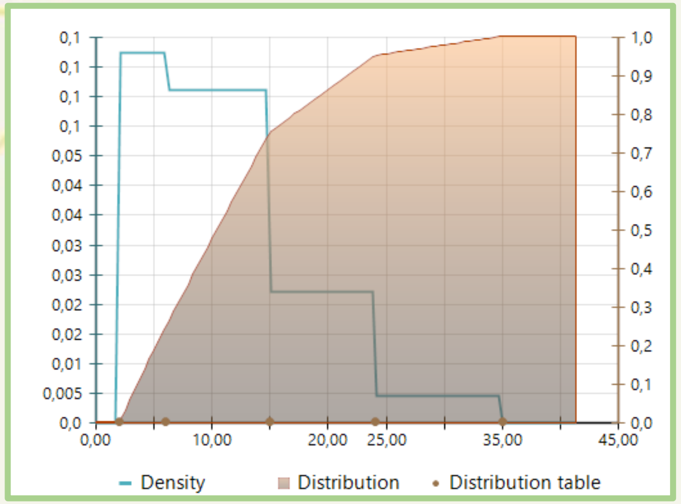
Ebro Basin Region,
NE of Spain
Campo de Belchite, Zaragoza


Ebro Basin Region,
NE of Spain
Campo de Belchite, Zaragoza

Ebro Basin Region description

- Onshore development
- 1600 md, sandstone
- Horst and graben system
- Possible compartmentalization
- Primary seal, secondary (regional) seal
- Focus on STORAGE operation from CCS chain
- Full life cycle evaluation: exploration, **pilot**, commercial operation and abandonment
- Walk the path and documented for future investors

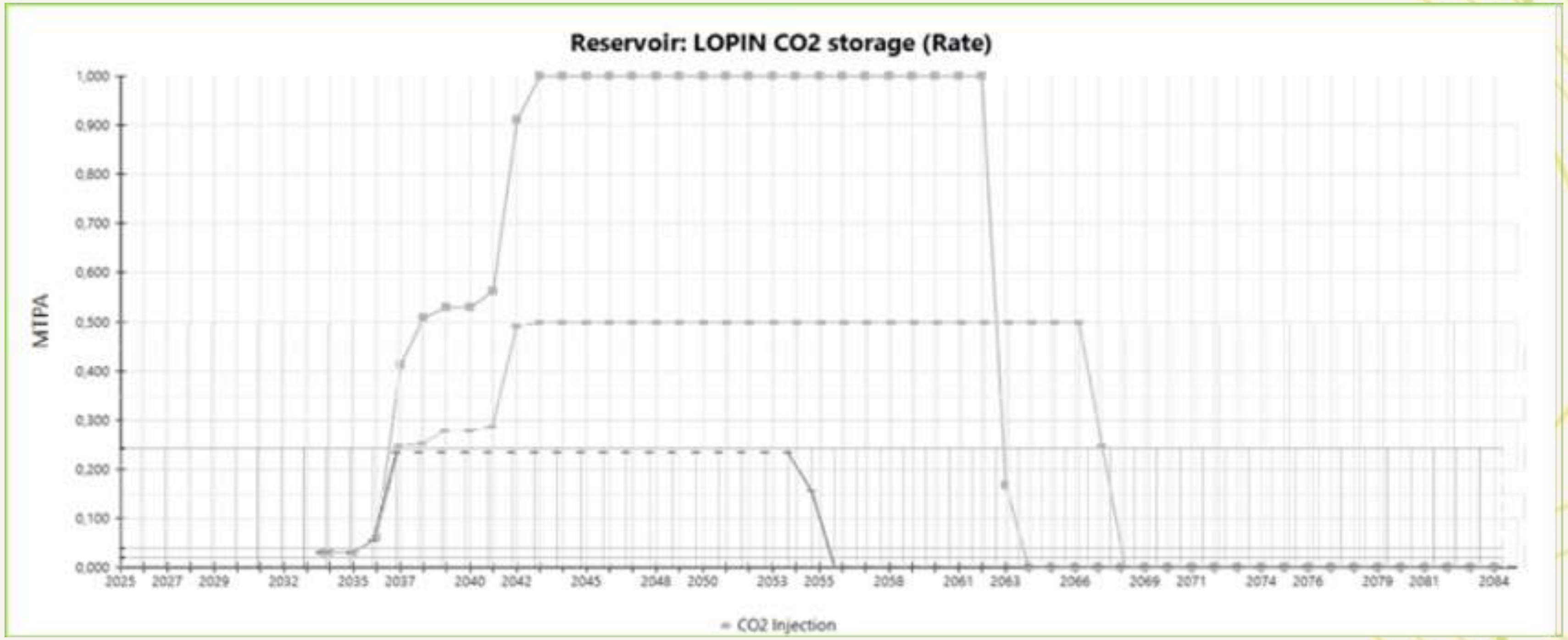
Development concept definition



	x	p
1	2,00	0,00
2	6,00	0,25
3	14,92	0,75
4	24,00	0,95
5	35,00	1,00

Lopin estimated capacity

CASE	Estimated capacity (Mt)	Injector wells (units)	Well Injection rate pilot (3 years)	Well Injection rate commercial
Case 1	[2, 7)	1	0.03 MTPA	0.25 MTPA
Case 2	[7,15)	2	0.03 MTPA	0.25 MTPA
Case 3	[15, 35]	2	0.03 MTPA	0.50 MTPA



Development concept

Cases 1	exploration	monitoring	Injector wells	Injection rate	Deterministic case
Between 2 and 7 MM tonne (WP3 case)	2D seismic + 1 exploration well	Baseline + 1 Injector sensors+ 1 water well + microsismisity+inSAR+ CO2 soil	1	0,03 Mt/year @ 3 years; 0,25 Mt/year thereafter.	5 MMtonnes Facilities CAPEX. 7 MM€; OPEX, 3.5 MM€; Abandon: 5,6 M€ Baseline: 0,48 MM€
Cases 2	**exploration**	**monitoring**	**Injector wells**	**Injection rate (per well)**	**Deterministic case**
Between 7 and 15 MM tonne (WP3 case)	2D seismic + 1 exploration well	Baseline+Injector sensors+ 2 water well + microsististity+inSAR+CO2 soil	2	0,03 Mt/year @ 3 years; 0,25 Mt/year thereafter.	14,9 MMtonnes Facilities CAPEX. 17 MM€; OPEX, 4 MM€; Abandon: 7,5 M€ Baseline: 0,68 MM€
Cases 3	**exploration**	**monitoring**	**Injector wells**	**Injection rate (per well)**	**Deterministic case**
Between 15 and 35 MM tonne (no compartimentalization)	2D seismic + 1 exploration well	Baseline+ Injector sensors+ 2 water well + microsististity+inSAR+ CO2 soil	2	0,03 Mt/year @ 3 years; 0,5 Mt/year thereafter.	25 MMtonnes Facilities CAPEX. 20 MM€; OPEX, 5 MM€; Abandon: 8,5 M€ Baseline: 0,8 MM€

MMV Plan

Baseline Definition
- 3D seismic
- Groundwater, soil, air
- Natural seismicity

Pressure Management
- Fiber-optic monitoring
- Continuous pressure control

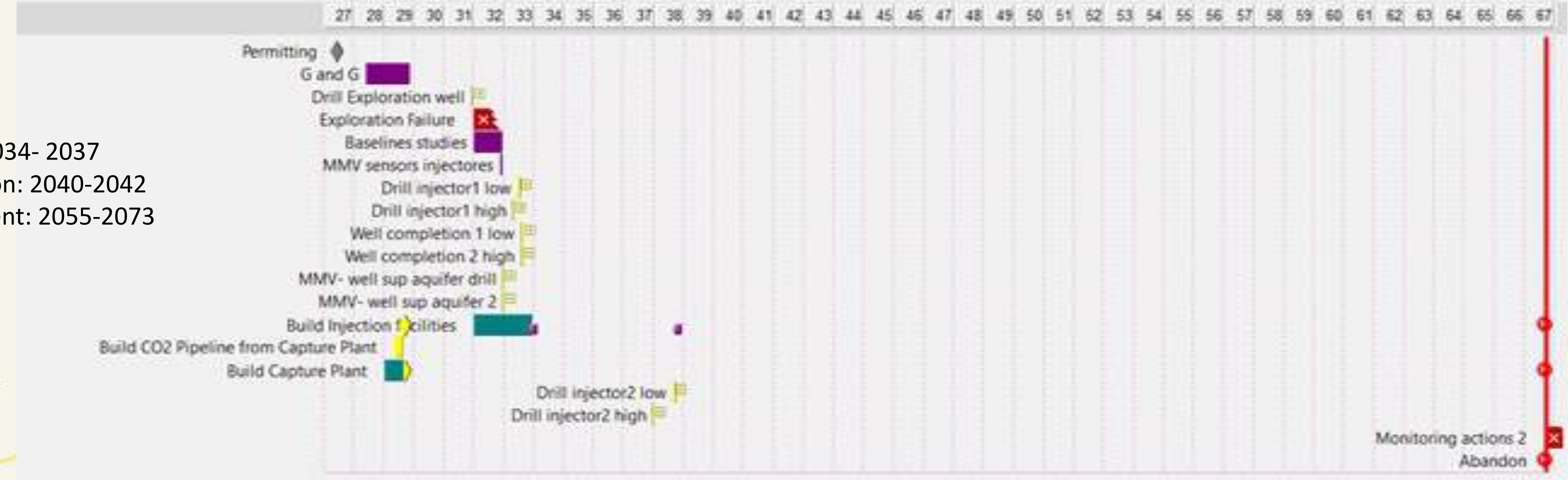
Induced Seismicity Monitoring
- Fiber optics
- Downhole geophones
- Surface seismometers

Well Integrity
- Operational integrity checks
- Integrity log pre-abandonment

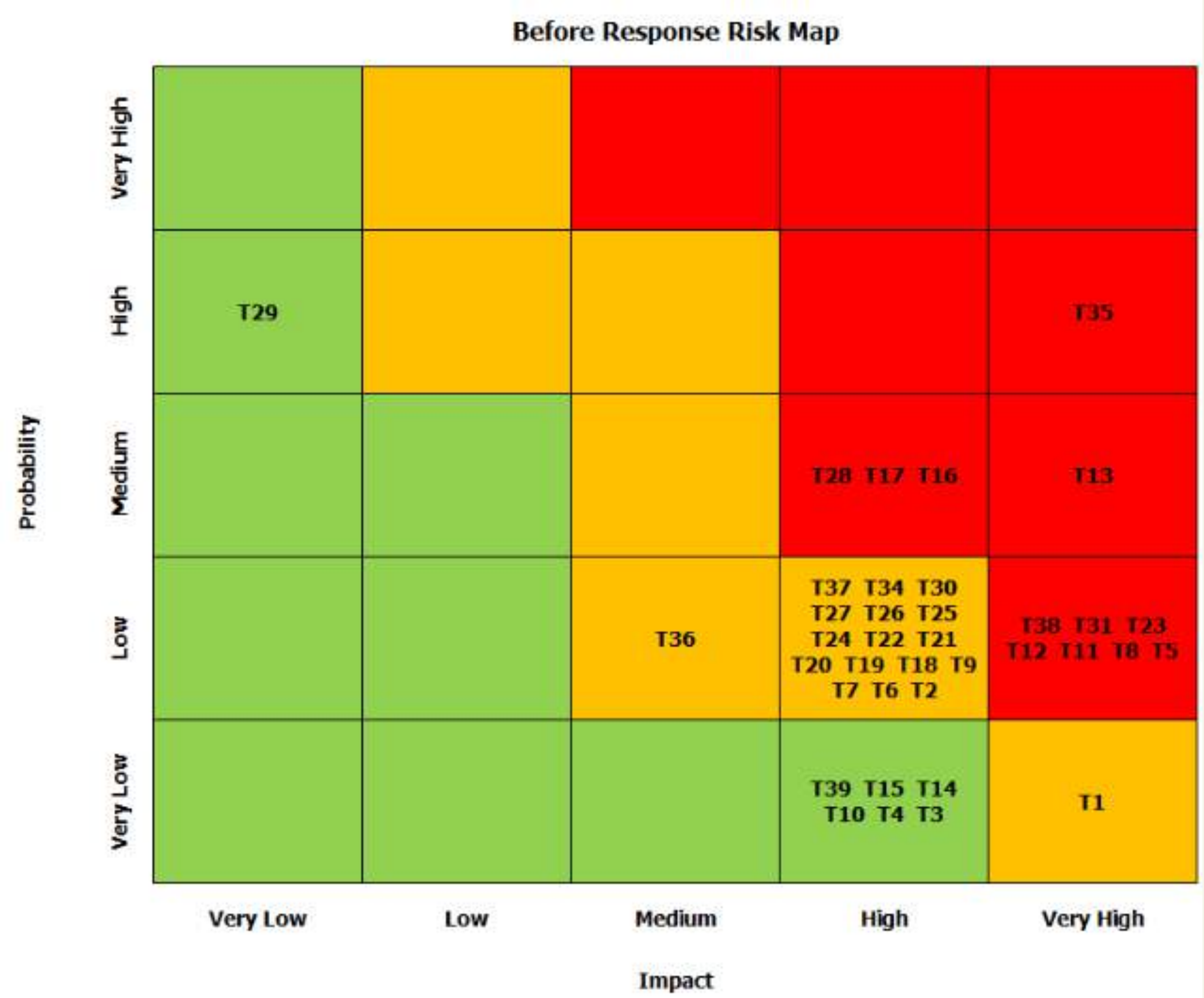
CO_2 Plume Monitoring
- Fiber-optic VSP (< ~2 km)
- Surface 4D seismic (if required)

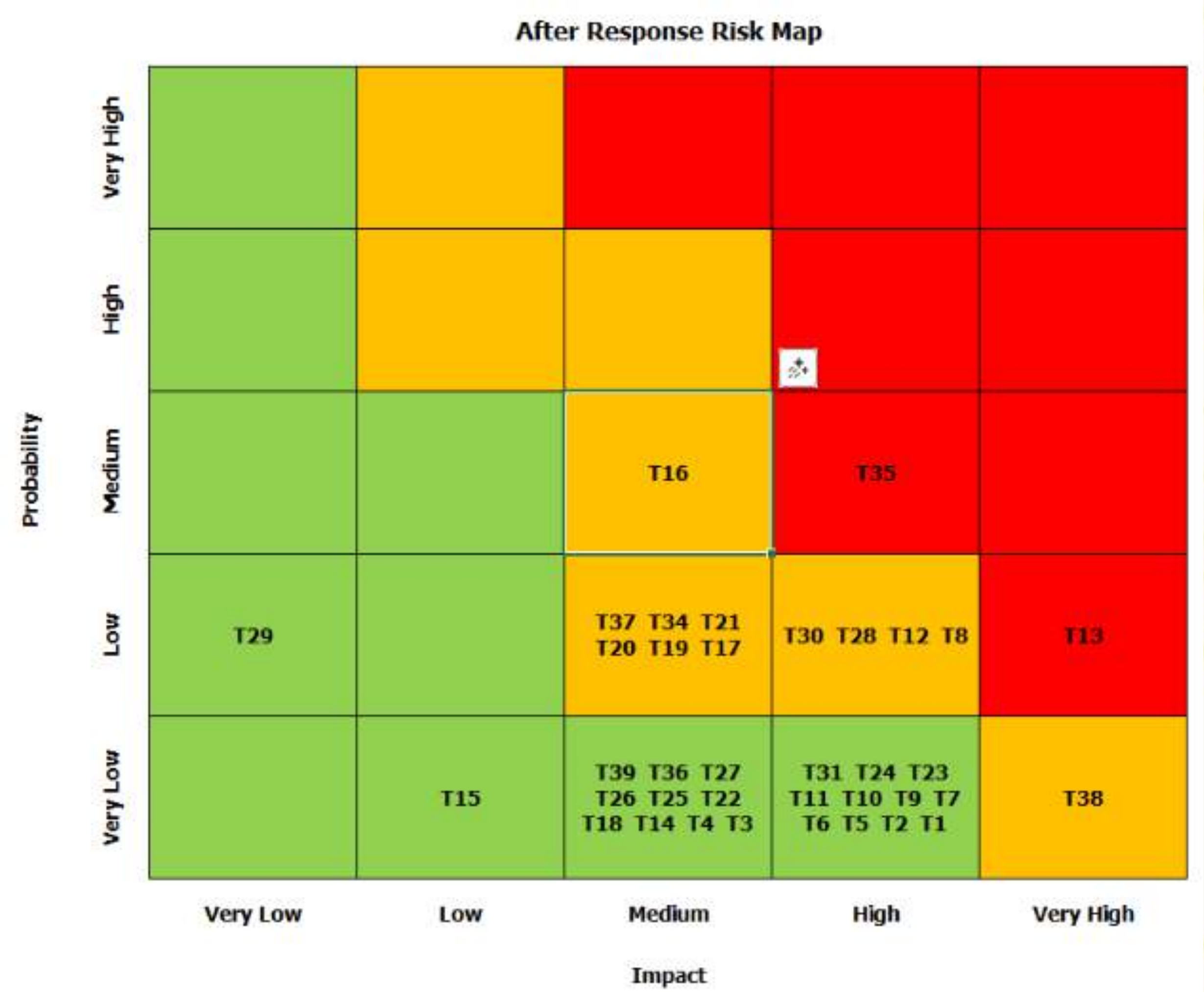
Environmental Monitoring
- Groundwater, soil & air
- Satellite InSAR

Start: 2027
Injection: 2034- 2037
Max injection: 2040-2042
Abandonment: 2055-2073



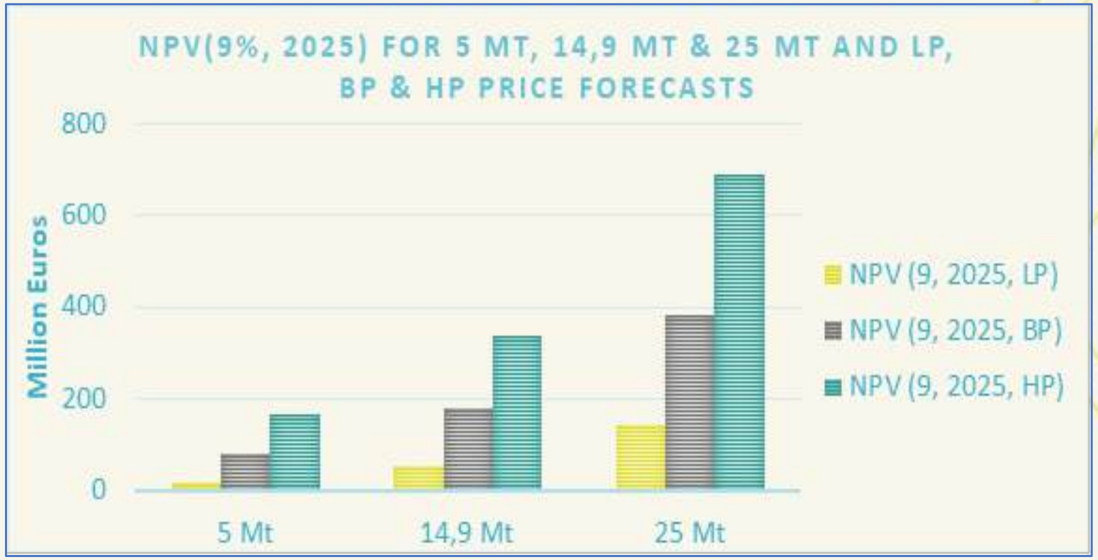
Multicriteria Risk identification





Risk matrix following Repsol methodology before and after response
T35: Unstable political support and regulatory uncertainty
T13: Unexpected compartmentalization

Economic assessment: Deterministic approach



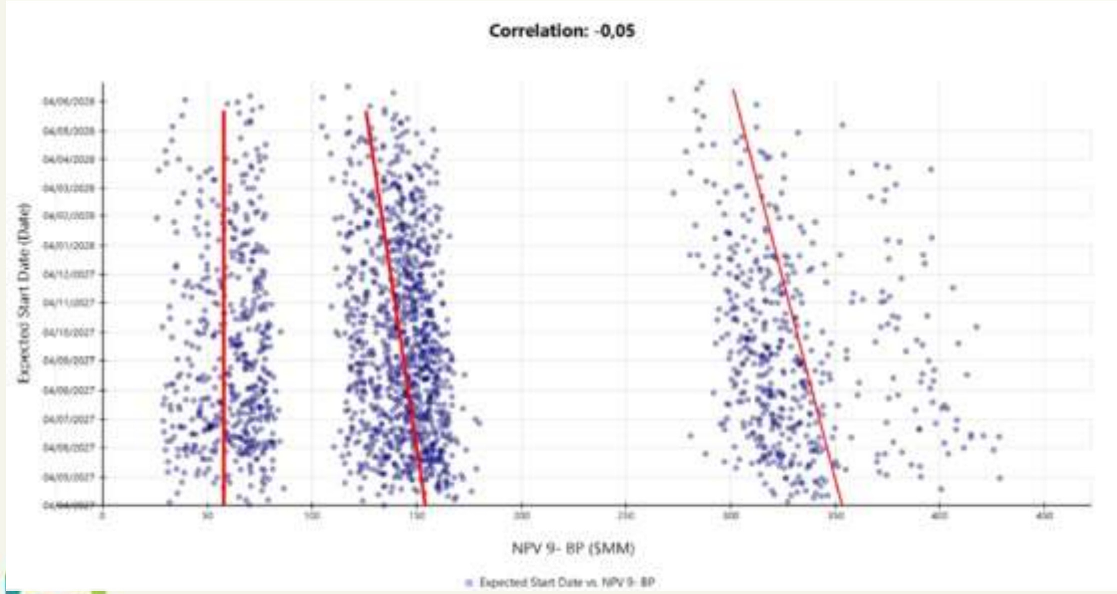
i: 2.2%; 9%; BP, HP, LP; 2025; Class IV costs
ETS Market@2030: 75 to 200 **€/tonne injected**
Discounted cashflow model
From Exploration to abandonment

Case	CAPEX (Million€)	OPEX (Million€)	Max Cash out (Million€)	Breakeven (€/tonne)
5 Mt	65	135	-37	**73**
14,9 Mt	99	275	-49	**42**
25 Mt	105	280	-64	**27**

Probabilistic Economic assessment

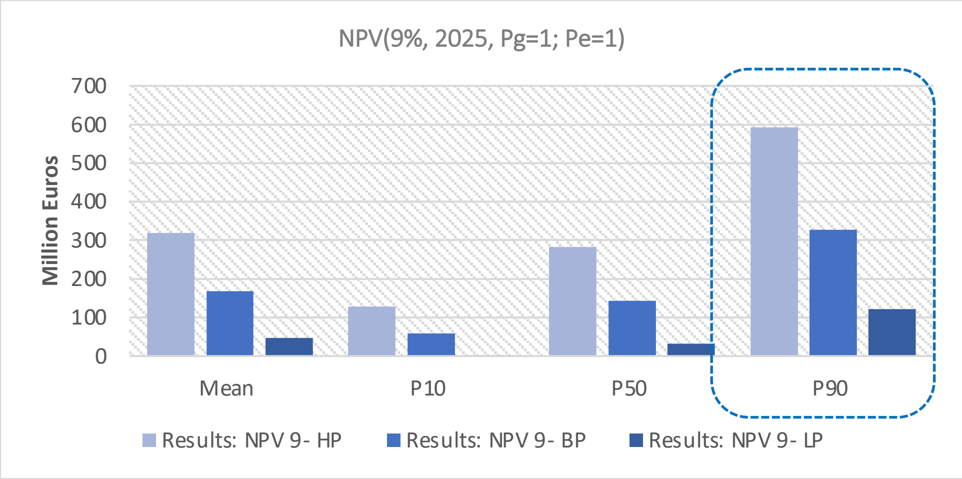
Probabilistic case studied	Pg	Pe
Success case	1	1
Geological success impact	0.6	1
Geological and pilot success impact	0.54	0.46

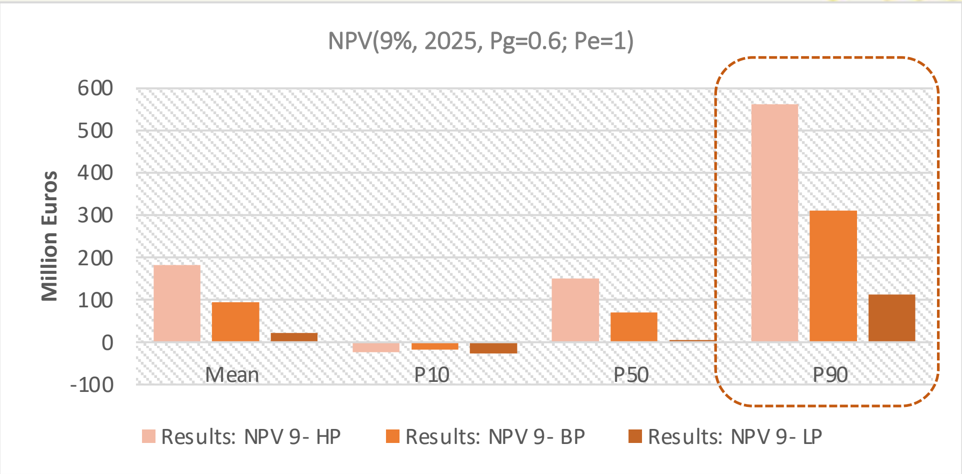
Pg: Chance of geological success; Pe: Chance of exploitation success

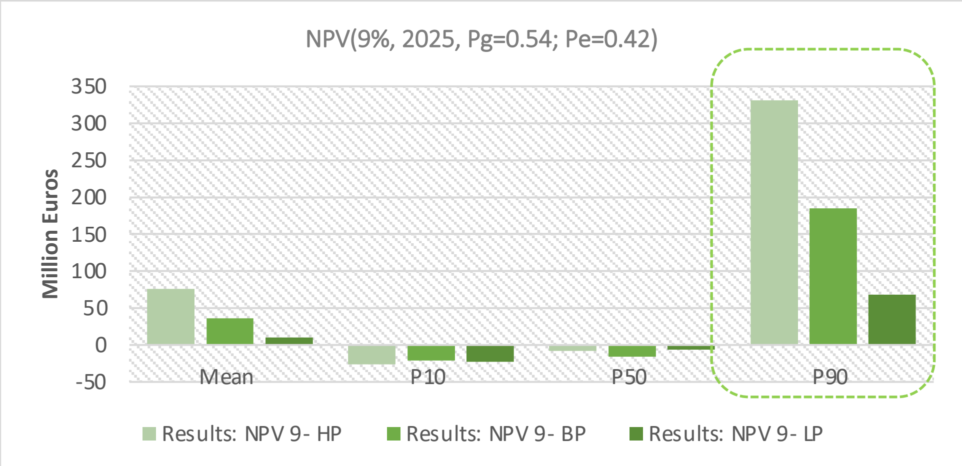


Impact on NPV of 1 year permit delay

10.000 MC simulations, PetroVR







SWOT ANALYSIS

Strengths
- Uniform, well-known regional geology
- Proven storage; regional caprock
- Very low natural seismicity
- Sparsely populated rural area
- Regional govt with CO_2 storage experience
- Receptive local stakeholders

Weaknesses
- Few and old subsurface data
- No seismic survey covering the area
- Possible compartmentalization
- Uncertainty about CO_2 source and purchase cost for the pilot

Opportunities
- Develop local industry
- Direct Air Capture potential (renewable energy)
- Community co-design model
- Proximity to regional industrial area

Threats
- Exploration license application time
- Uncertainty in national CCS policy support
- Uncertain access to EU/national funds for the pilot

Way forward

- Main impact definition of compartmentalization: exploration campaign.
- Social acceptance: local stakeholders show conditional openness; contingent on trust, transparent information, and tangible local benefits. Sustained engagement required from exploration through commercial phase.
- No barriers on regulation at regional level (exploration) – no clear for national permit (commercial operations).
- High value on the high side of capacity estimation: strong case if it is verified.
- Potential for local development: DACs to be checked.

Thank you for listening!

Peñas Royas, Teruel. Proyecto PilotSTRATEGY

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PilotSTRATEGY

Lusitanian Basin, Portugal

A pilot to enable industrial-scale CCS

UNIVERSIDADE DE ÉVORA

galp

ICS INSTITUTO DE CIÊNCIAS SOCIAIS

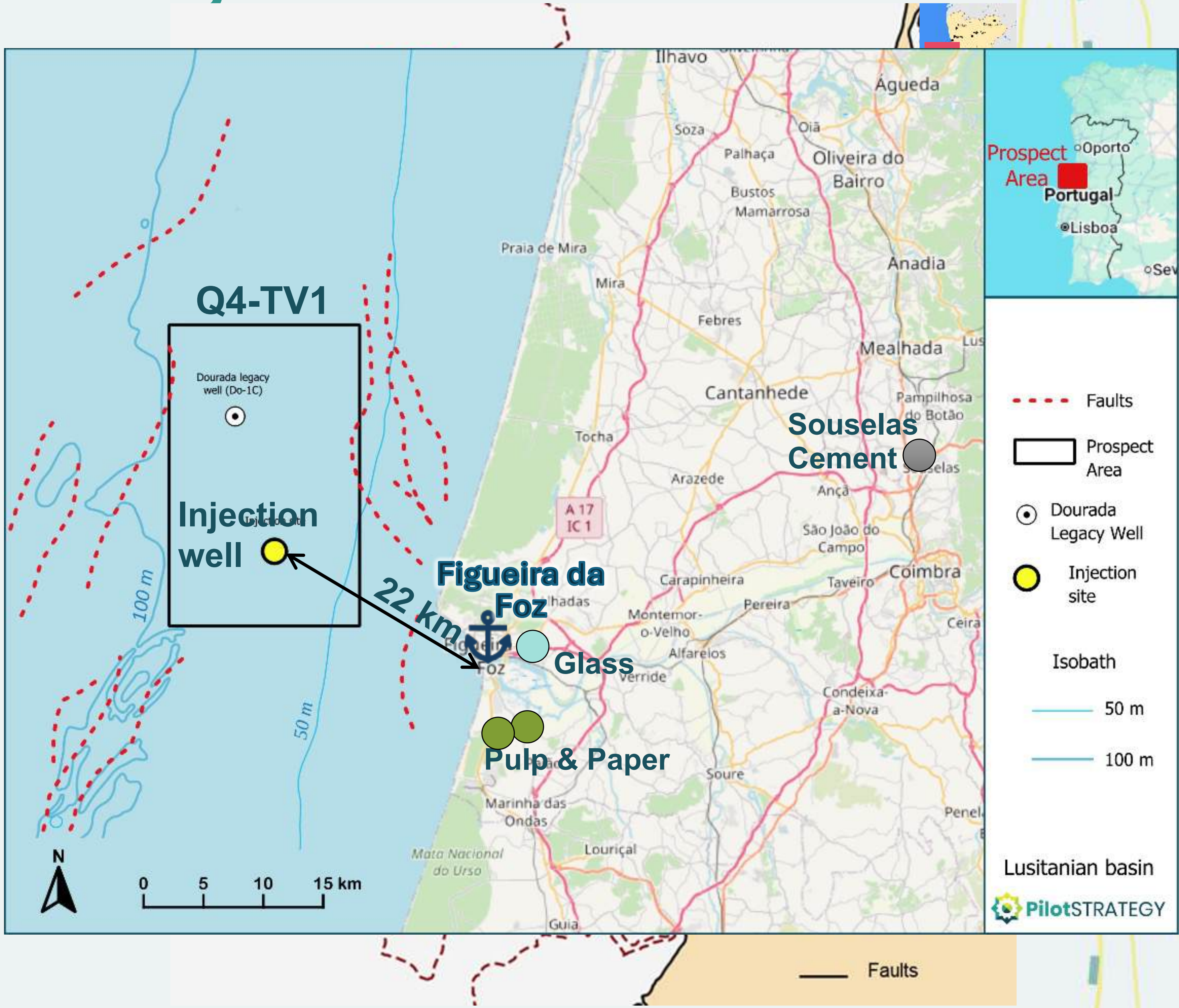
PilotSTRATEGY Final Event, 21-22 April 2026, Brussels

Site location: offshore for scalability

Offshore enables the scale Portugal needs for CO_2 storage.

Prospect Q4-TV1

- **Excellent reservoir quality**
- **Low** active seismicity
- Conditions for **safe storage**
- Dynamic storage capacity > **93 Mt CO_2**
- Around 20 km from **Figueira da Foz Port**

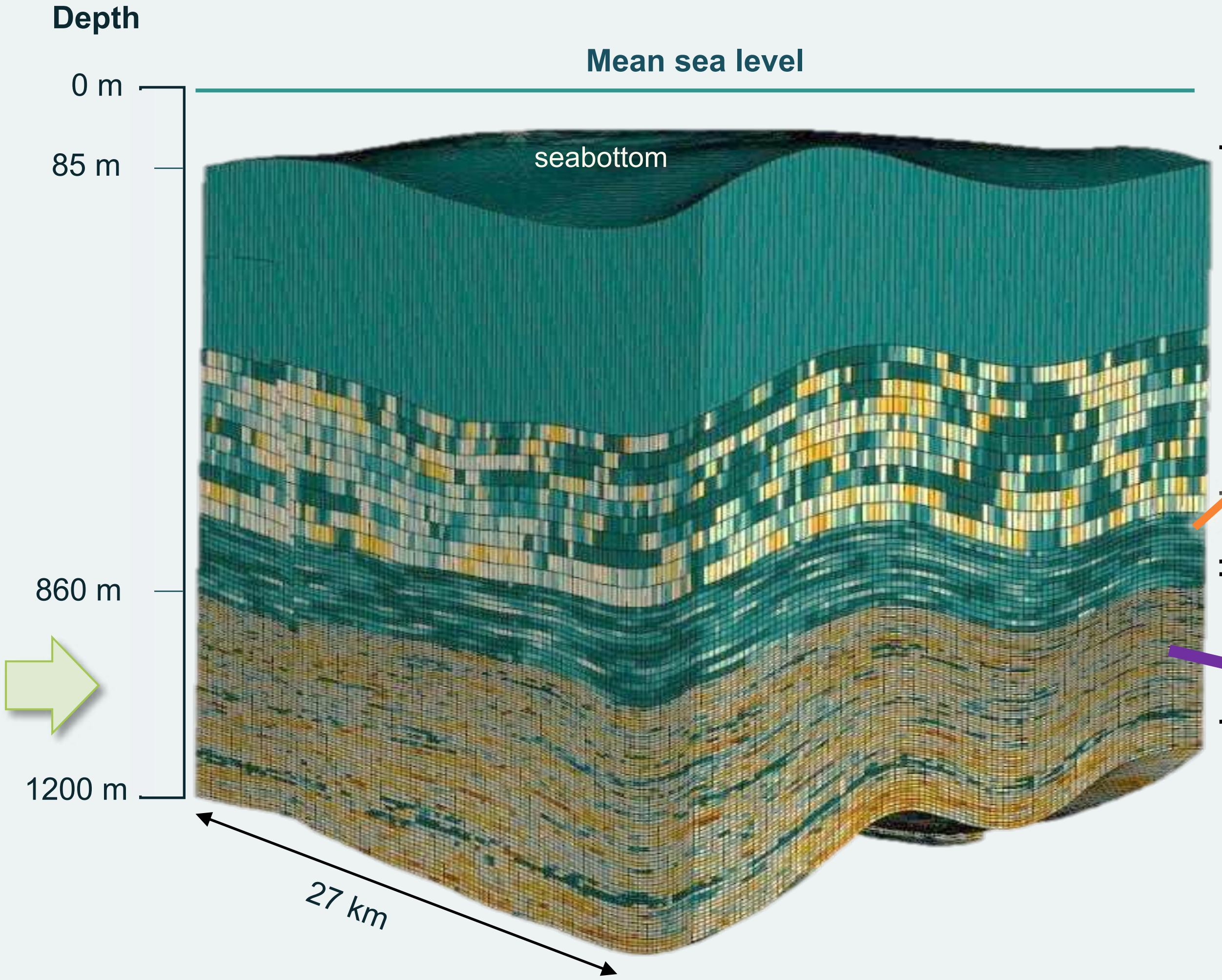


Storage complex

- **Water Column Depth*:** 85m
- **Reservoir Top Depth*:** 860m
- **Reservoir Bottom Depth*:**1200m
- **Reservoir Thickness*:** 300m
- **Petrophysical Properties*:**

  Reservoir: ϕ = 22% | k = 229mD

*Average Value



Pilot concept - maximise flexibility

STRATEGY

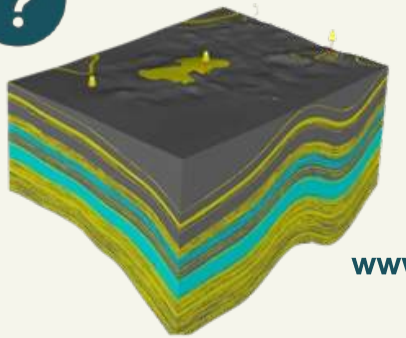
- Avoid permanent or non-reusable equipment in the commercial phase
- Integration with pilot capture at Souselas cement factory

TRANSPORT SOLUTION

- Intermodal transport
- Cryogenic containers by rail and ship
- Injection directly from the ship

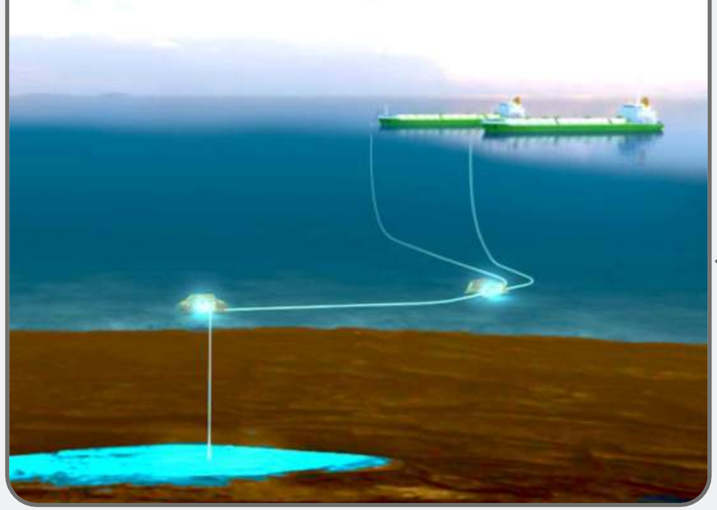
STORAGE SOLUTION

- Test the offshore storage complex
- **Injection up 100 kt/CO_2 (DL 60/2012)**
- Minimize interference with other socio-economic activities



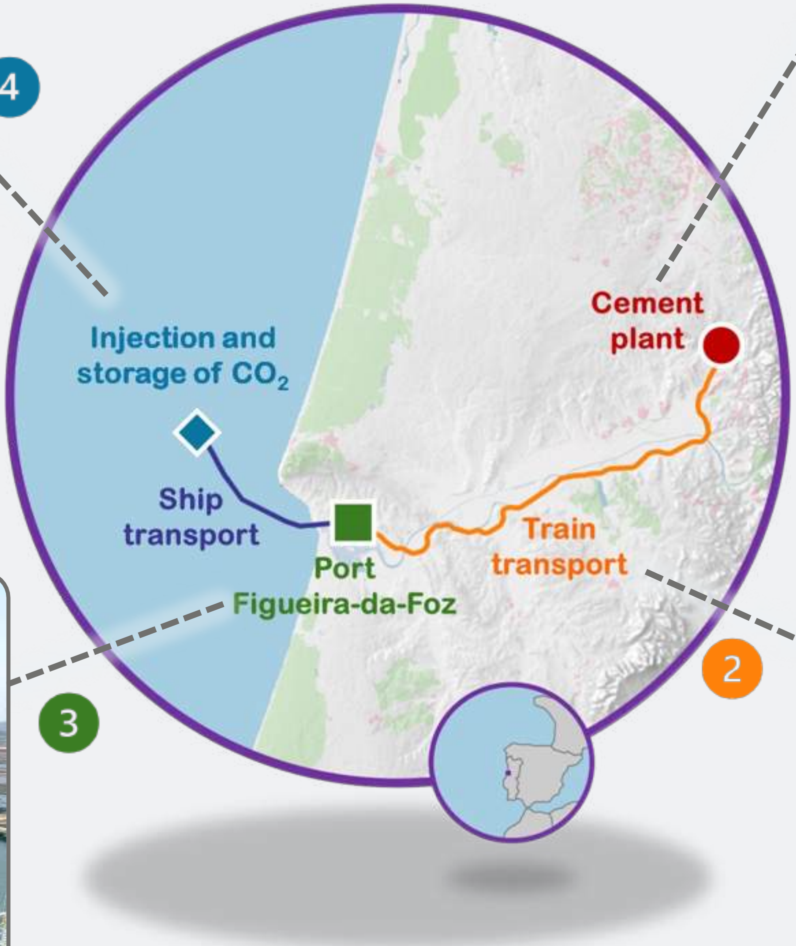
Intermodal transport

Transport and injection by ship



Injection period 12-15 months

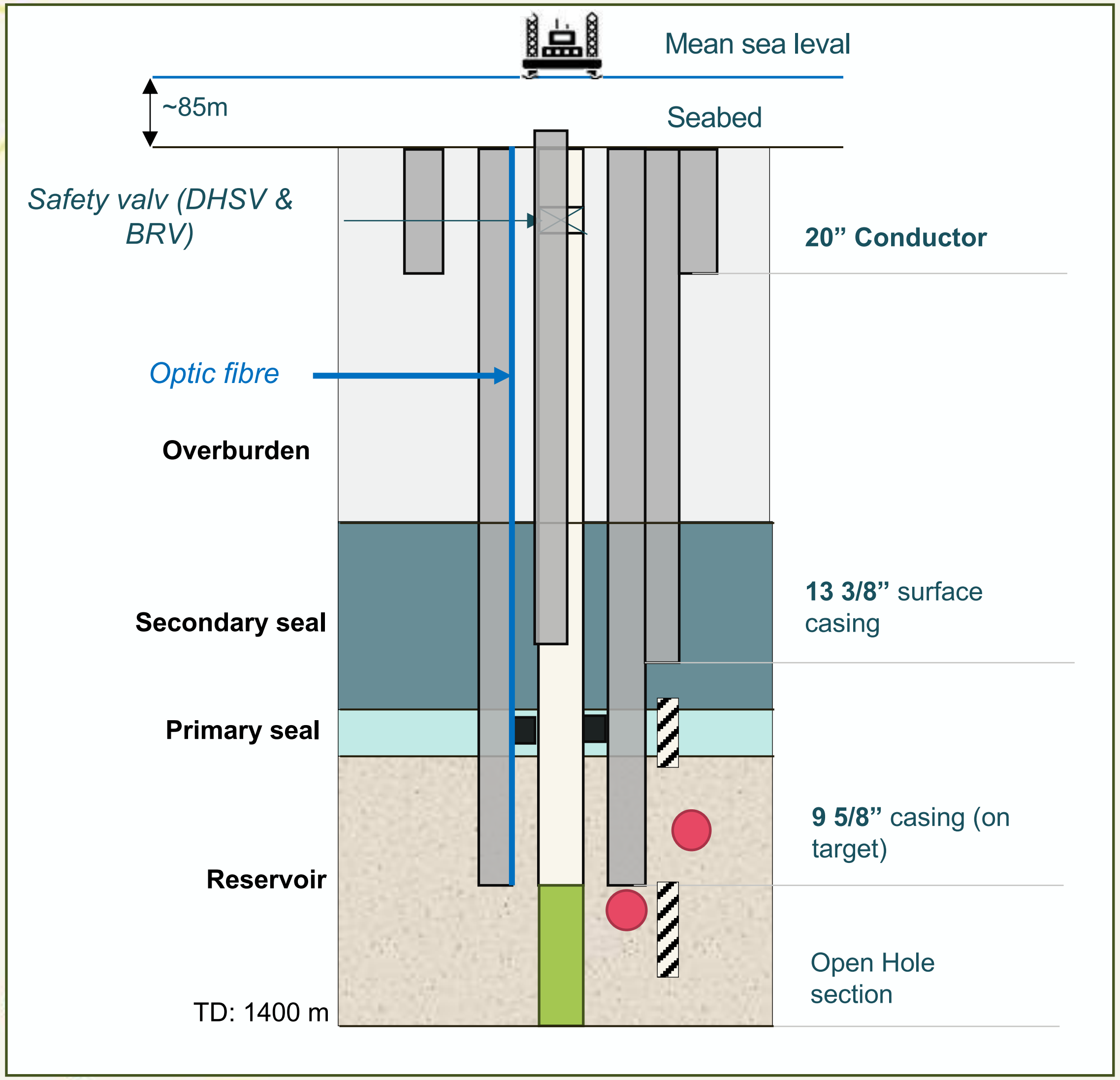
<100 kton CO_2



Cryogenic containers, 23.5 ton CO_2 (P=15bar, T=-29°C)

Train,
~650 ton CO_2

Injection well design



- **Single well for Pilot Phase**
- No monitoring wells
- **Injection rate: 0.5 – 1.1 Mton/ano**
- Commercial phase implies multiple injection wells

Injection intervals

- 1025–1065 m
- 1155–1205 m

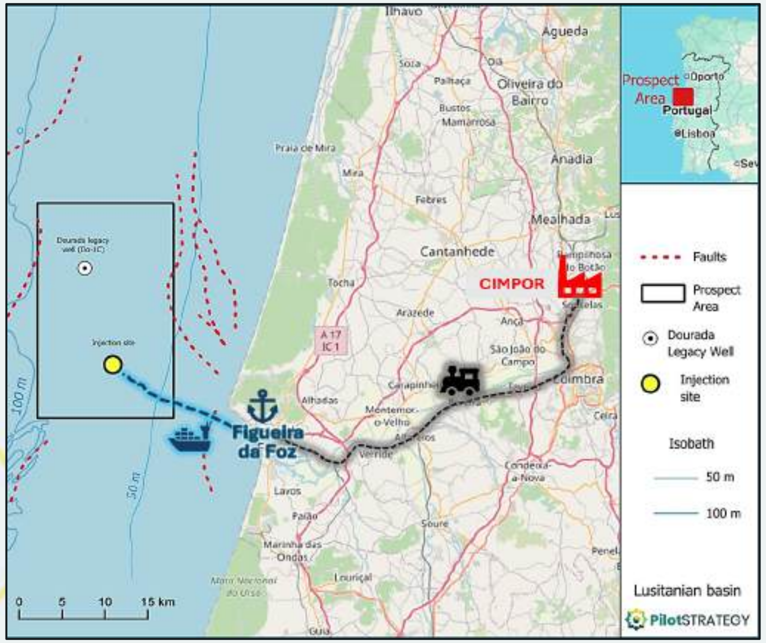
Injectivity test
Core Interval (2 x 20 m)
Packer

Project Timeline – from pilot to commercial

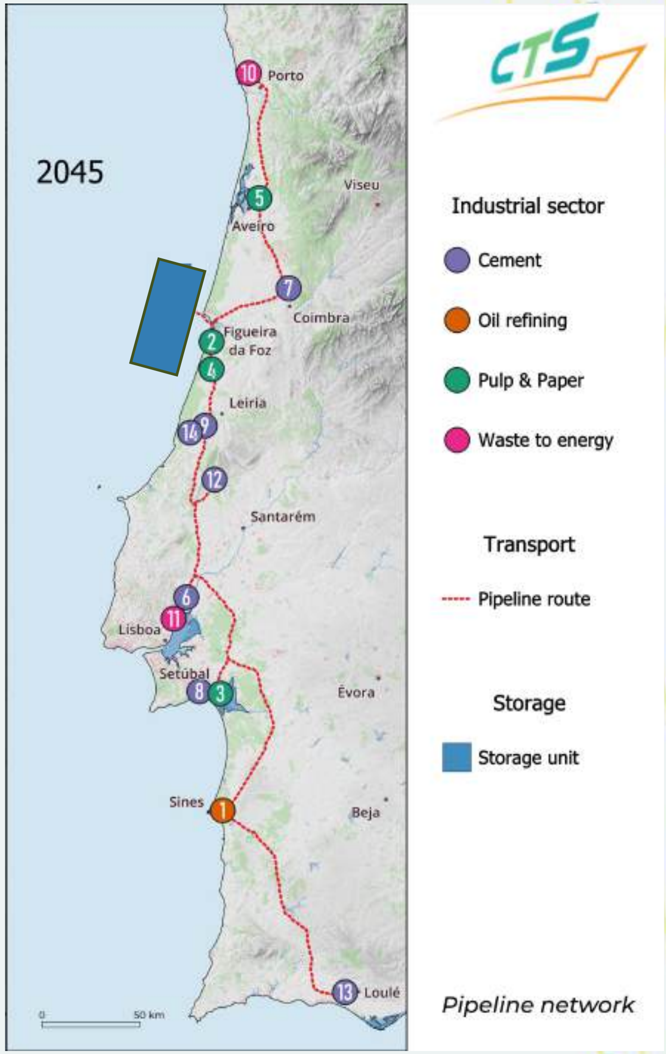
Clear decision gate for large-scale CCS deployment in Portugal

Commercial phase - a country scale solution

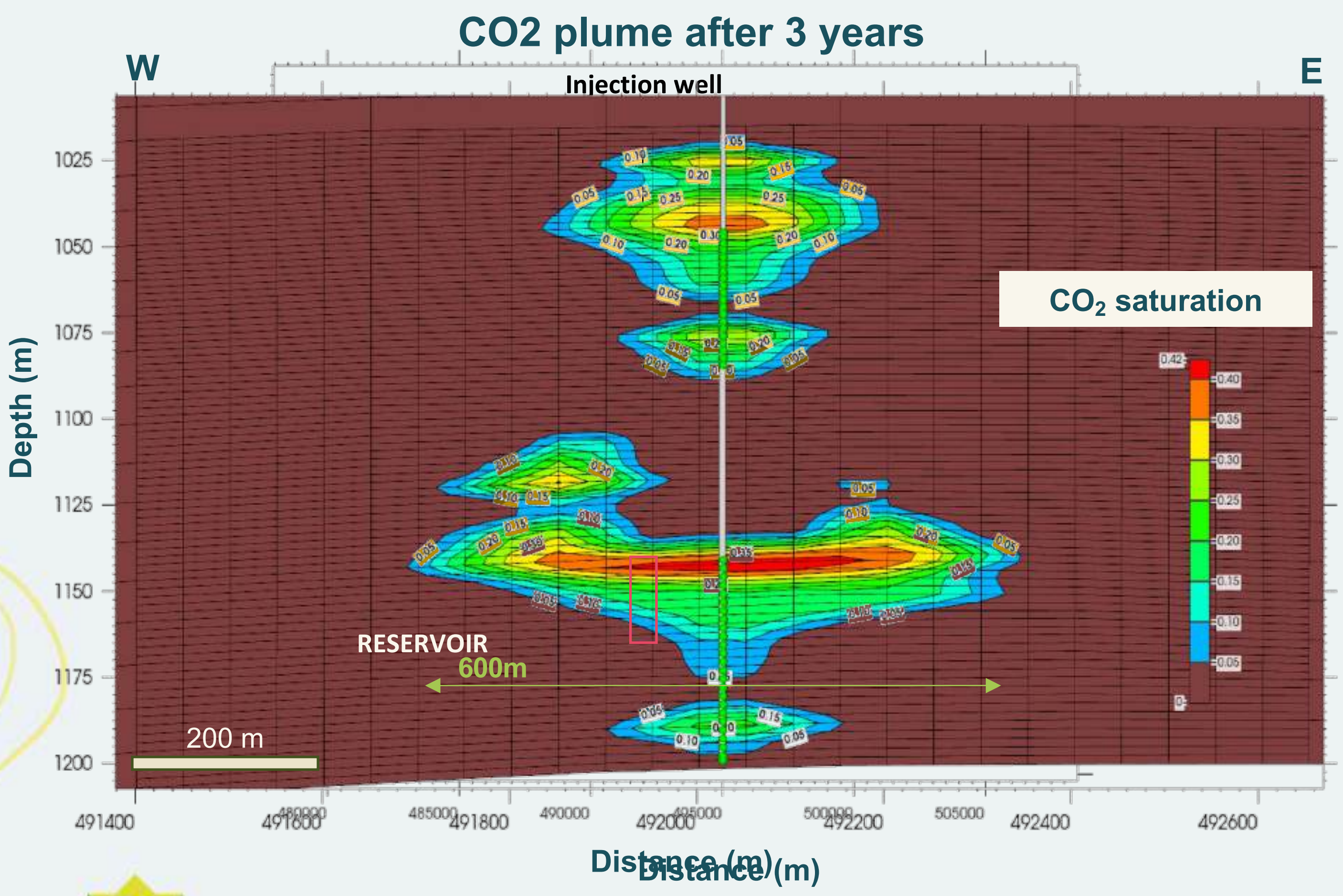
2031

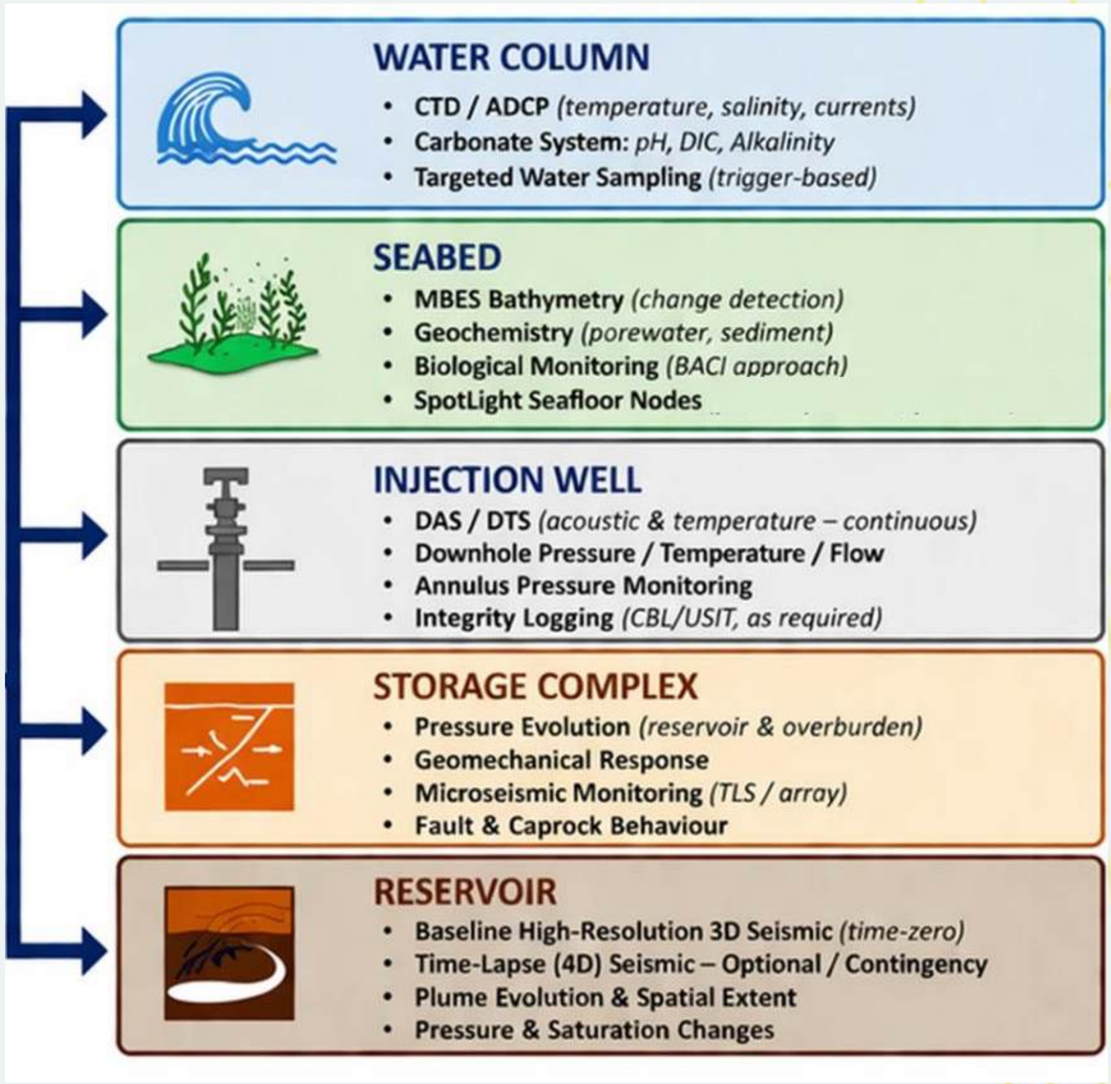


2040



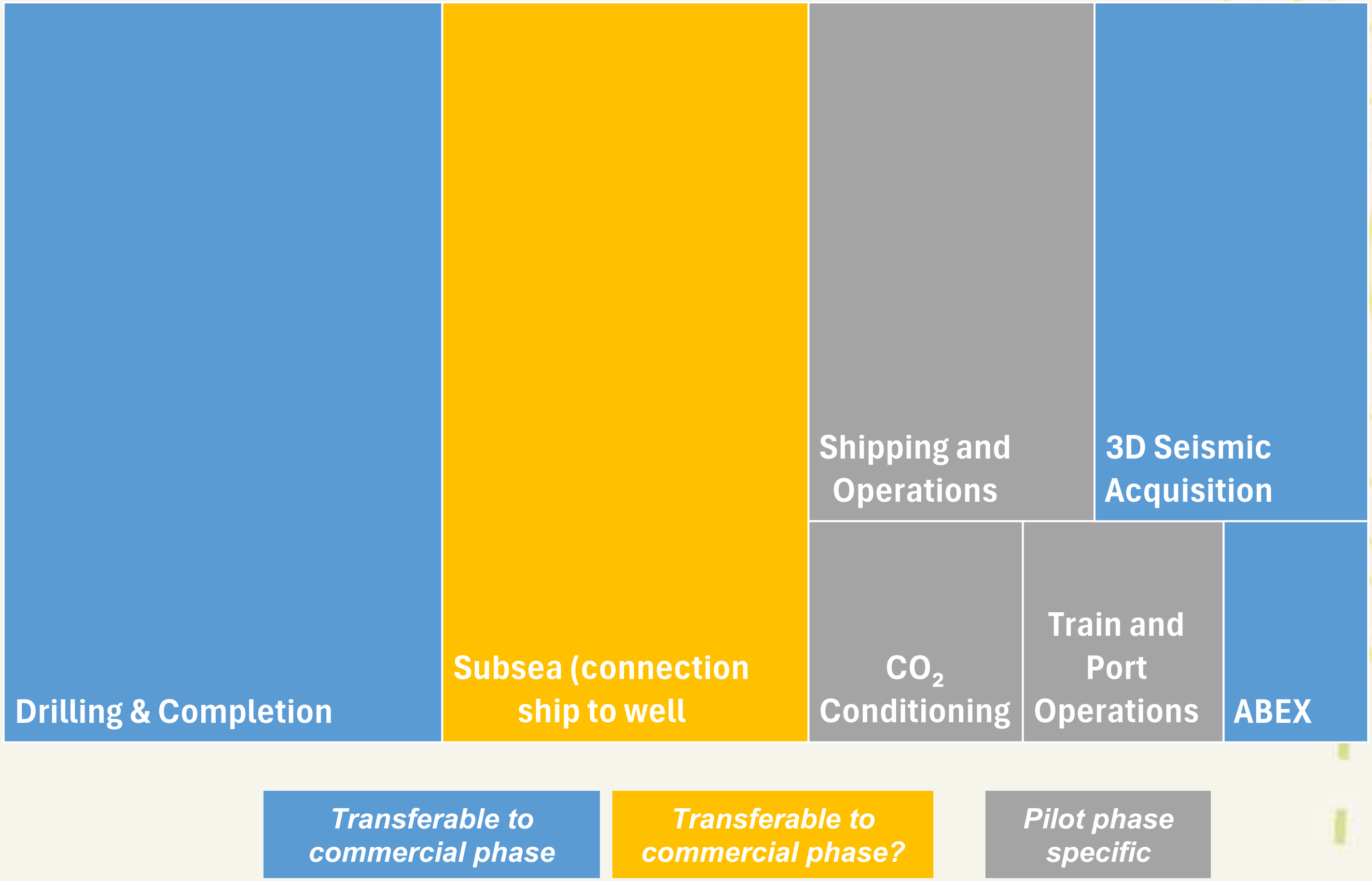
MMV architecture





Cost structure of the pilot

COMPONENT	SUB-TOTAL (M€)
CO_2 Conditioning	4.6
Train and Port Operations	4.3
Shipping and Operations	14.4
Subsea (connection ship to well)	26.3
Drilling & Completion	31.5
3D Seismic Acquisition	13.8
ABEX	3.1
Total	**98**



- Well and offshore infrastructure main components.
- Part of costs reusable in a commercial phase.
- **The pilot is not designed to be profitable — it is designed to reduce risk.**

Safety and performance risks

- Low global risk, with no critical scenarios identified
- CO_2 plume remains confined in the reservoir, without reaching faults or abandoned boreholes
- Cap-rock maintains integrity under operating conditions
- Identified uncertainties can be mitigated with operational monitoring and control

Risk Matrix (Pilot Phase)

	Impact				
	Very Low	Low	Medium	High	Very High
Very High	R21	R32	R36		
High			R18	R43	
Medium	R9p, R41	R10p, R19, R20, R30, R37, R39, R49	R31, R46	R23, R24, R42, R44, R45	
Low	R8p, R13, R25	R47	R14, R17, R40	R15	
Very Low	R2p, R5p, R11p, R16, R26, R38	R6p, R7p, R27, R29, R34, R35	R22, R48	R3p, R4p, R12, R28, R33	R1p

Pilot implementation risks

MAIN CRITICAL RISKS

- Regulatory and permitting risks
- Political and institutional readiness,
- CO_2 supply and funding constraints,

MAIN STRENGTHS

- **Scalable** offshore storage;
- Adapted to **regulatory constraints**;
- Intermodular transport - **flexibility**.

MAIN WEAKNESSES

- **High costs** due offshore setting;
- Maturity of **Direct injection from Ship**;
- **Regulatory issues.**

SWOT

MAIN OPPORTUNITIES

- **Technical and regulatory knowledge**;
- Support **hard-to-abate sectors;**
- Enables Carbon Neutrality in 2045

MAIN THREATS

- **Delays** from permitting;
- **Cost instability** for offshore;
- **No continuity** to commercial.

Key takeaways

- Portugal has identified a credible candidate site for offshore CO_2 storage.
- **A pilot project is necessary to kick-start CCS in Portugal while regulatory constrains for commercial scale are addressed.**
- The pilot should start in 2027 to allow commercial project in 2034. Move forward now!
- The pilot project is not a cost – neede for to achieve **carbon neutrality** and to decarbonize **hard-to-abate** sectors.
- **The main constraints are now institutional, not technical:**
  - **political support**, maritime planning for CO_2 storage, subsurface governance, CO_2 transport regulations, legal clarity and inter-authority coordination.

Thank you for listening

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Assessing CO_2 Storage Potential in Western Macedonia, Greece

Brussels, 21 April 2026

Dr. Nikolaos Koukouzas (CERTH), Dr. Pavlos Tyrologou (CERTH), Ms. Christina Karatrantou (CERTH), Dr. Christos Stergiou (CERTH), Dr. Dimitrios Ktenas (HEREMA), Dr. George Makrodimitras (HEREMA), Dr. Konstantinos Tzimeas (HEREMA), Dr. Efthimios Tartaras (HEREMA)

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

CCS and the European Climate Strategy

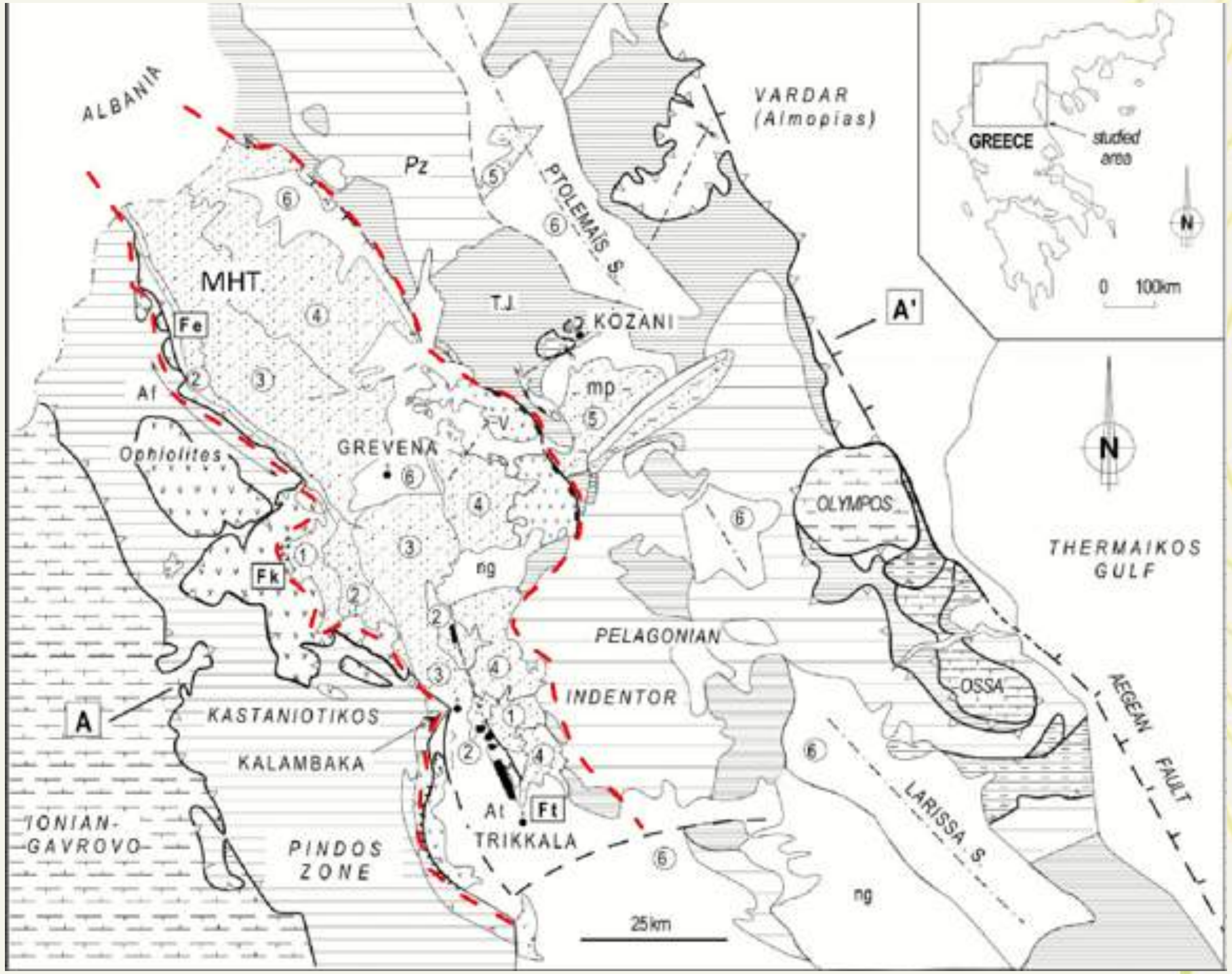
- CCS is essential for achieving EU climate neutrality targets
- Critical for decarbonizing hard-to-abate industrial sectors
- Europe requires new geological storage sites
- South-Eastern Europe remains underexplored

Why Western Macedonia

- Former lignite energy hub of Greece
- Rapid undergoing energy transition of the region
- Existing energy infrastructure and technical expertise
- Strategic location within emerging CCS networks in South-Eastern Europe
- Greece is actively advancing CCS deployment (e.g., Prinos CO_2 storage project and National CCS framework)

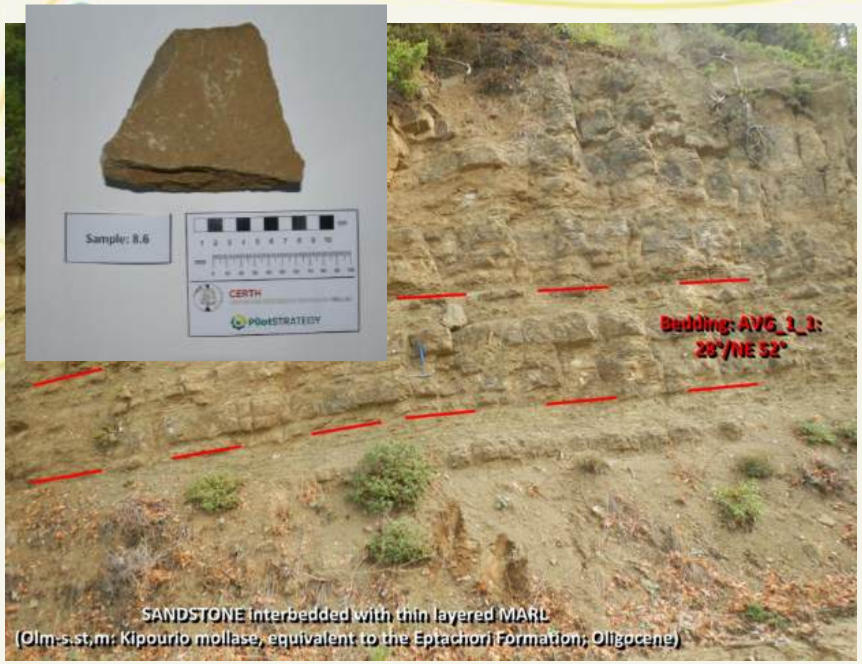
The Mesohellenic Trough

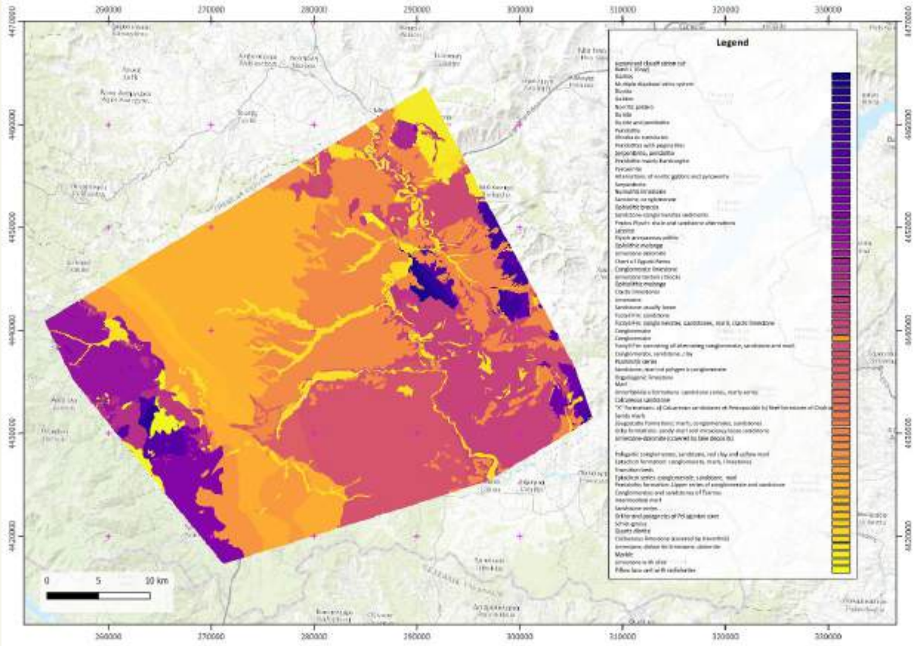
- Large molassic basin of the Hellenides
- Approx. 200 km long and 30–40 km wide
- Oligocene–Miocene sedimentary successions
- Potential reservoir–seal geological architecture

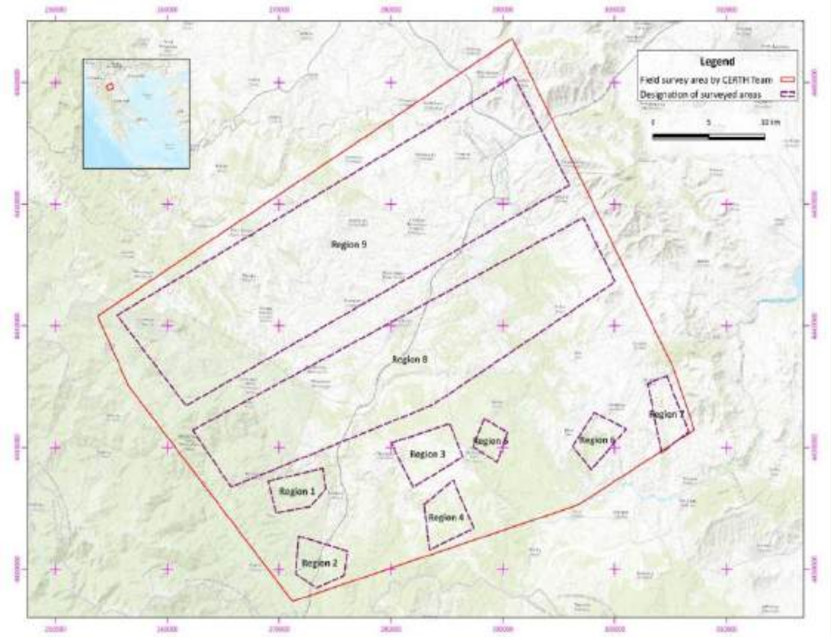


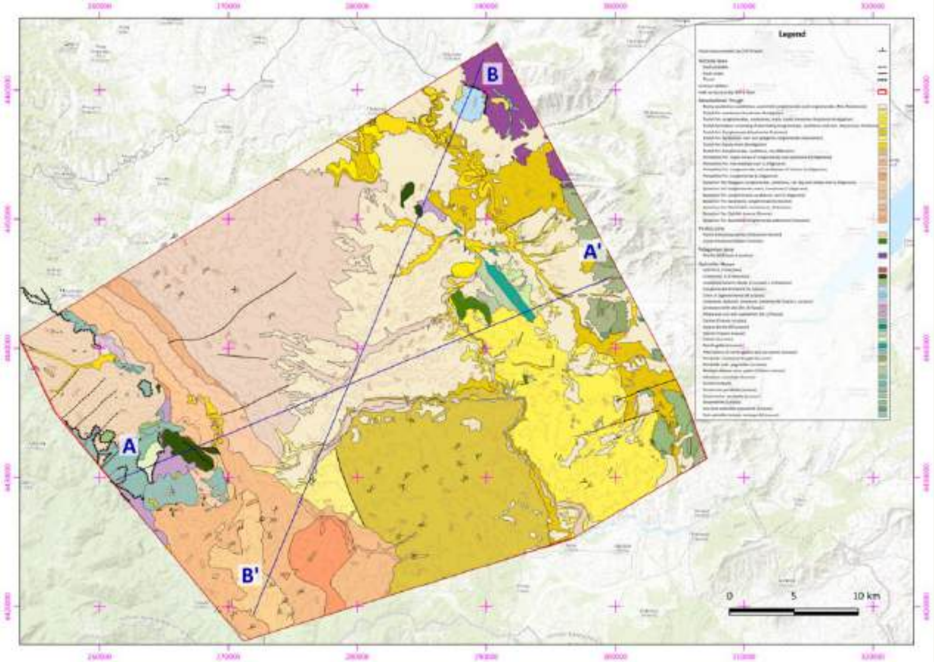
Simplified geological map of the Mesohellenic Trough (MHT), outlined with red dashed lines, and the broader geological framework[3]. 1 to 4: main formations (Fms) of the MHT, 1: Krania Fm (late Eocene), and 2: Eptachori Fm (Early Oligocene), 3: Pentalofos Fm (Late Oligocene-Ealry Miocene), 4: Tsotyli and Ondria Fms (Early- Middle Miocene), 5: Ptolemais basin (late Miocene-Pliocene, mp), 6: recent deposits. Abr. Ng : Neogene, Pz: Paleozoic, TJ: Triassic and Jurassic, V: Vourinos massif, S: synclines, A: anticlines (i.e., Af: Filippi anticline, At: Theopetra-Theotokos anticline), Bold lines and Fe, Fk, Ft: major tectonic contacts and faults; lines with black triangles: Tertiary back-thrusts or main reverse series; Dashed lines: normal faults (Ferriere et al., 2004)

Field mapping & remote sensing integration









Scope

Field campaigns (2021–2025) across nine regions in West Macedonia.	Geological mapping, structural logging, and sampling (>80 sites), following ISO 14689:2017 and BS 5390:2015+A1:2020

Highlights

Alternating sandstones, marls, and conglomerates forming effective reservoir-seal pairs	NE-dipping strata and Felli Fault Zone define main structural controls	120 rock & 38 water samples collected and registered in SESAR2

Remote sensing analysis

Sentinel-2 MSI imagery integrated with field observations	Remote sensing refined lithological boundaries of Tsotyli, Pentalofos & Eptachori formations

Outcome

Field data confirm a multi-layered, structurally stable system suitable for CO_2 storage	Results form the basis for lab analyses and geological modelling

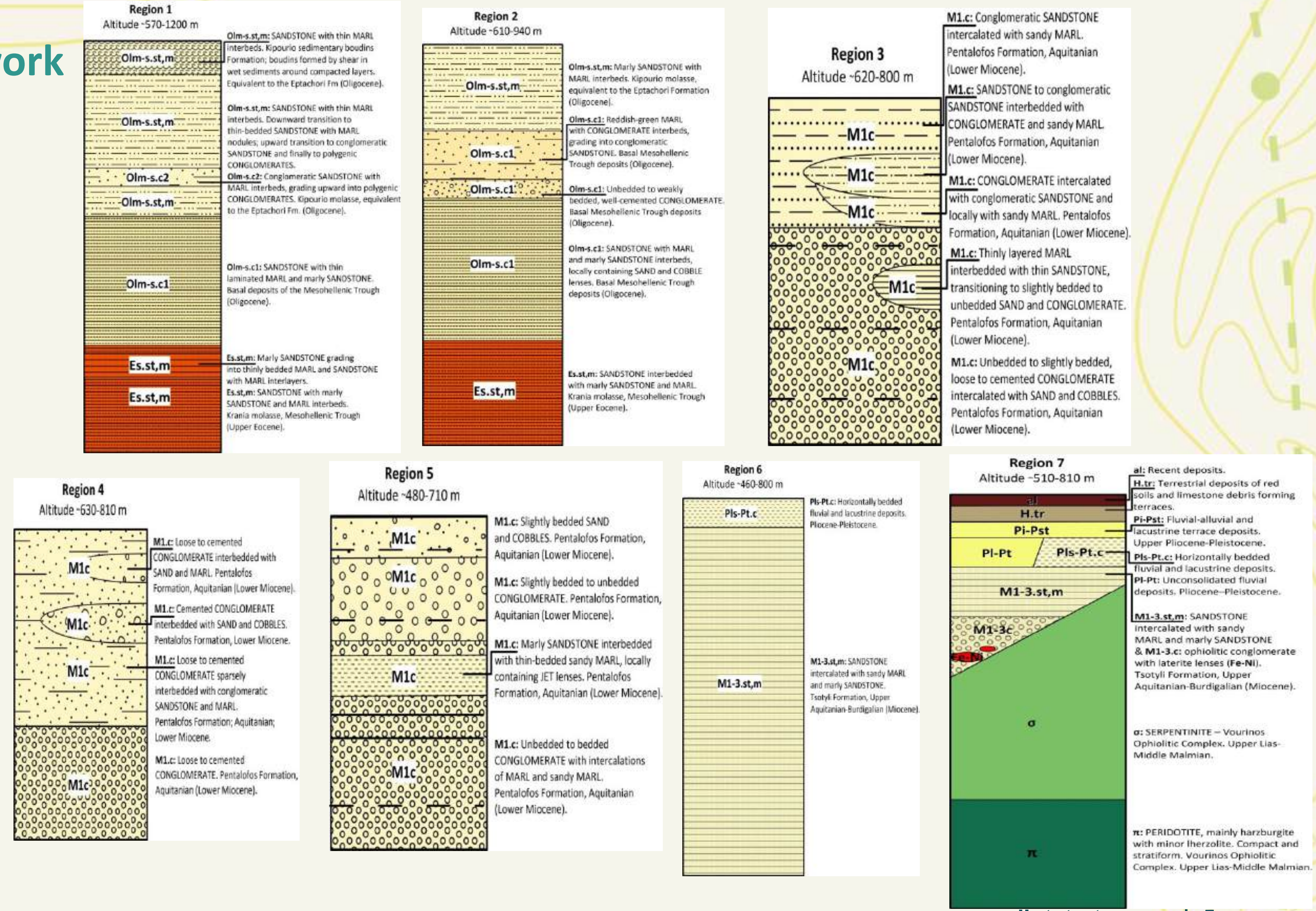
Stratigraphic Framework

Key formations

- **Eptachori Formation** – sandstone-dominated units with reservoir potential
- **Pentalofos Formation** – thick turbiditic sandstones and conglomerates with reservoir potential
- **Tsotyli Formation** – marl-rich succession acting as regional seal

Key characteristics

- Oligocene–Miocene molassic basin
- Alternating **sandstone–marl sequences**
- Formation of multiple **reservoir–seal pairs**



Geochemical and mineralogical characterisation of reservoir formations

Water absorption

0–500 ml H_2O / 1000 g rock

Inverse correlation with dry density

Rock type response

Sandstones, limestones, ultramafics → low uptake (<70 ml/1000 g), stable

Marly–clayey sediments → higher uptake (150–500 ml/1000 g), locally unstable

Carbonate-rich rocks

Minimal absorption (0–45 ml / 1000 g)

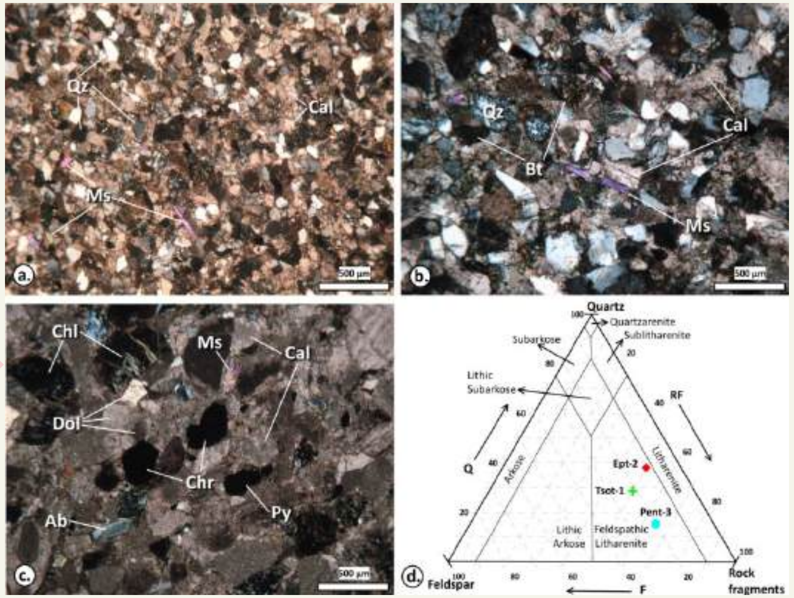
Matrix fabric & clay content

control water interaction

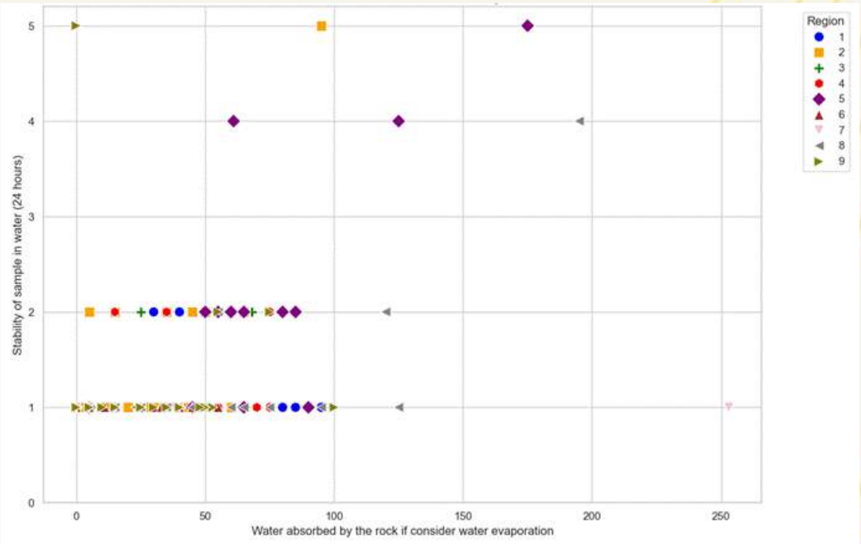
Regional behaviour

Most formations remain mechanically stable up to ~150 ml / 1000 g

Indicates well-cemented rock framework



Petrographic microphotographs illustrating mineral assemblages in representative sandstone samples.QFR diagram classifies the rocks as feldspathic litharenites (McBride, 1963)



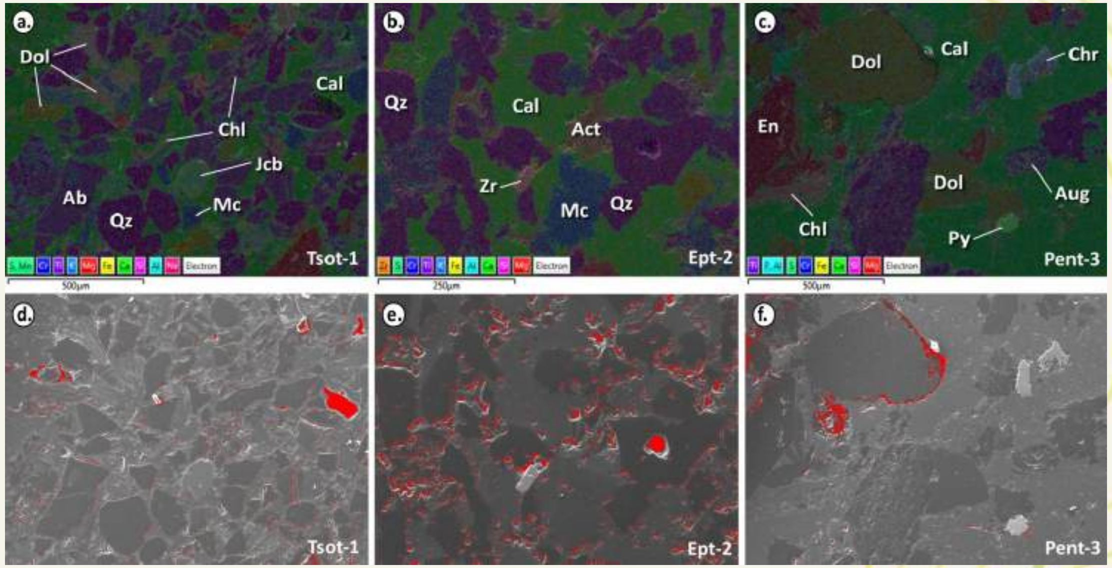
Water absorption vs. stability after 24 h immersion: most samples remain Grade 1 stable even at ~100–150 ml/1000 g.Higher absorptions are mainly associated with marly or poorly consolidated materials showing reduced stability.

Mineralogical controls on reservoir stability

(Koukouzas et al., (2025) Characterization of Sandstone Formations in the Mesohellenic Trough for CO2 Storage: Insights from the Integration of Optical Mineralogy, Geochemistry, and Automated Imaging Techniques)

Sandstones dominated by quartz, calcite and feldspars, with minor muscovite, chlorite and dolomite, forming well-cemented feldspathic litharenites derived from mixed siliciclastic–carbonate sources.

This mineralogical framework supports mechanical stability and favourable reservoir conditions for CO_2 storage.



Elemental mapping and automated image analysis of representative samples (Tsot-1, Ept-2, Pent-3). Porosity values range between ~1.1–1.9%

Geomechanical constraints on CO_2 storage formations

Laboratory analysis indicate low porosity and permeability in several sedimentary units

Measured UCS values confirm increasing mechanical competence across stratigraphic sequence

Tsotyli ≈ 22 Mpa

Eptachori ≈35 MPa

Pentalofos ≈74 MPa

Fine-grained intervals within Eptachori, Pentalofos and Tsotyli formations may act as effective caprocks

Safe CO2 storage requires injection pressures within geomechanical limits to prevent failure

Sample	Average V. (GPa)	Standard deviation
TS	22	1.7
EP	35	5.0
PE	74	8.0
Correlation C5 - UCS		

Laboratory-derived uniaxial compressive strength (UCS) values for representative formations of the Mesohellenic Basin, indicating increasing mechanical competence from Tsotyli to Pentalofos formations (Tyrologou et al., 2023)

Petrophysical Properties	Values	Sample code: EPT-2-3. WGS84 Lat : 40.1535, WGS84 Long : 21.0824
Porosity (%)	7.4	
Water Permeability (mD)	<0.01	
Formation Factor/m	123/1.46	
Clay bound water (fraction)	0.97	

Petrophysical Properties	Values	Sample code: PENT 3-2 WGS84 Lat : 40.1332 WGS84 Long : 21.1997
Porosity (%)	10.8	
Water Permeability (mD)	<0.01	
Formation Factor/m	46/1.72	
Clay bound water (fraction)	0.91	

Petrophysical Properties	Values	Sample code: PENT 3-3 WGS84 Lat : 40.1332 WGS84 Long : 21.1997
Porosity (%)	4.9	
Water Permeability (mD)	<0.01	
Formation Factor/m	157/1.68	
Clay bound water (fraction)	0.94	

Petrophysical Properties	Values	Sample code: PENT 3-1 WGS84 Lat : 40.1332 WGS84 Long : 21.1997
Porosity (%)	5.0	
Water Permeability (mD)	<0.01	
Formation Factor/m	112/1.58	
Clay bound water (fraction)	0.96	

Petrophysical Properties	Values	Sample code: TSO-1-3 WGS84 Lat : 40.3075 WGS84 Long : 21.3354
Porosity (%)	6.0	
Water Permeability (mD)	<0.01	
Formation Factor/m	273/1.99	
Clay bound water (fraction)	0.87	

Representative sandstone cores used for laboratory petrophysical and mechanical characterisation of potential CO_2 storage formations (Eptachori, Pentalofos, Tsotyli) (Tyrologou et al., 2023)

Laboratory petrophysical and geomechanical analyses demonstrate that the formations of the Mesohellenic Basin combine mechanical strength with low permeability horizons, providing favourable conditions for safe long-term CO_2 storage

Geochemical investigation

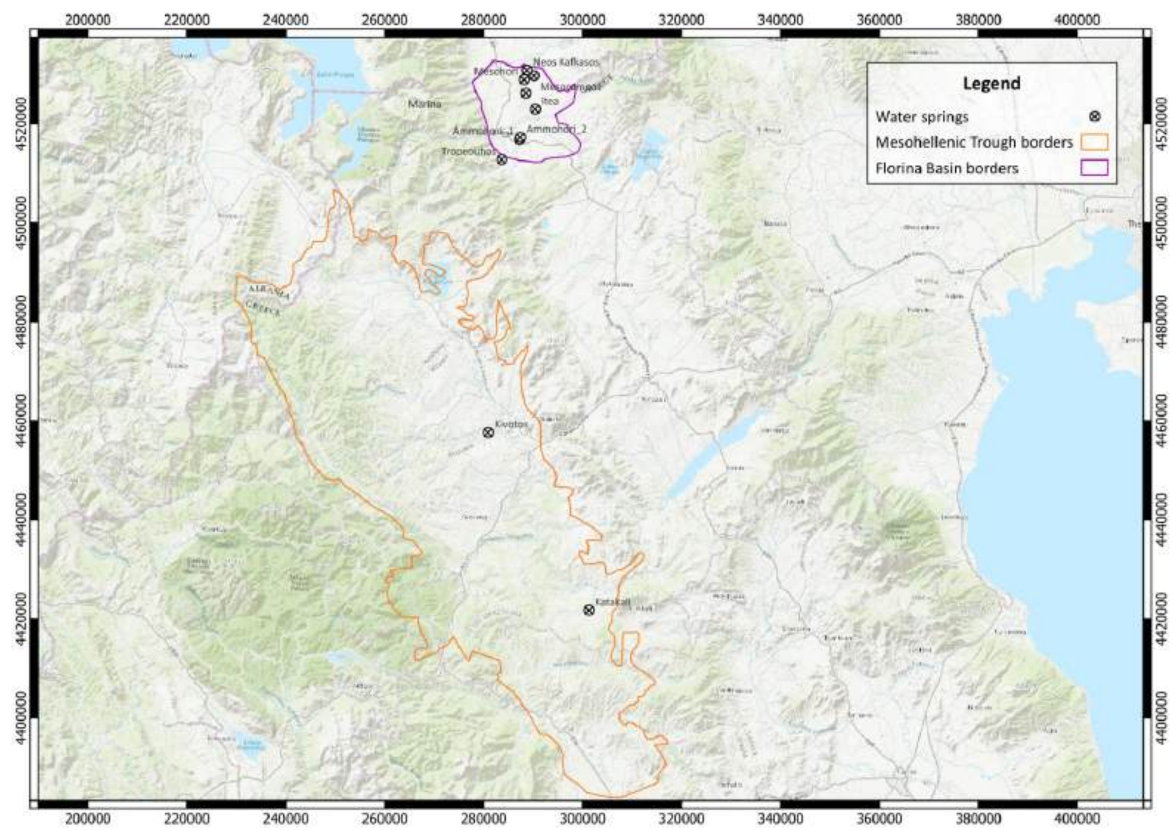
Assess the geochemical stability of the system and identify natural gases behaviour to understand CO_2 storage potential.

Groundwater shows **chemical stability** and low reactivity → favourable for CO_2 storage.

Detected gases:

- **CH_4:** up to 31 000 ppm → deep migration through faults.
- **H_2:** detected in Katakali → serpentinisation / organic origin
- **He:** up to 1 400 ppm → mantle or deep-crustal source.

δ[13]C–δ[18]O isotopes: near-equilibrium with carbonates → minimal alteration under CO_2.



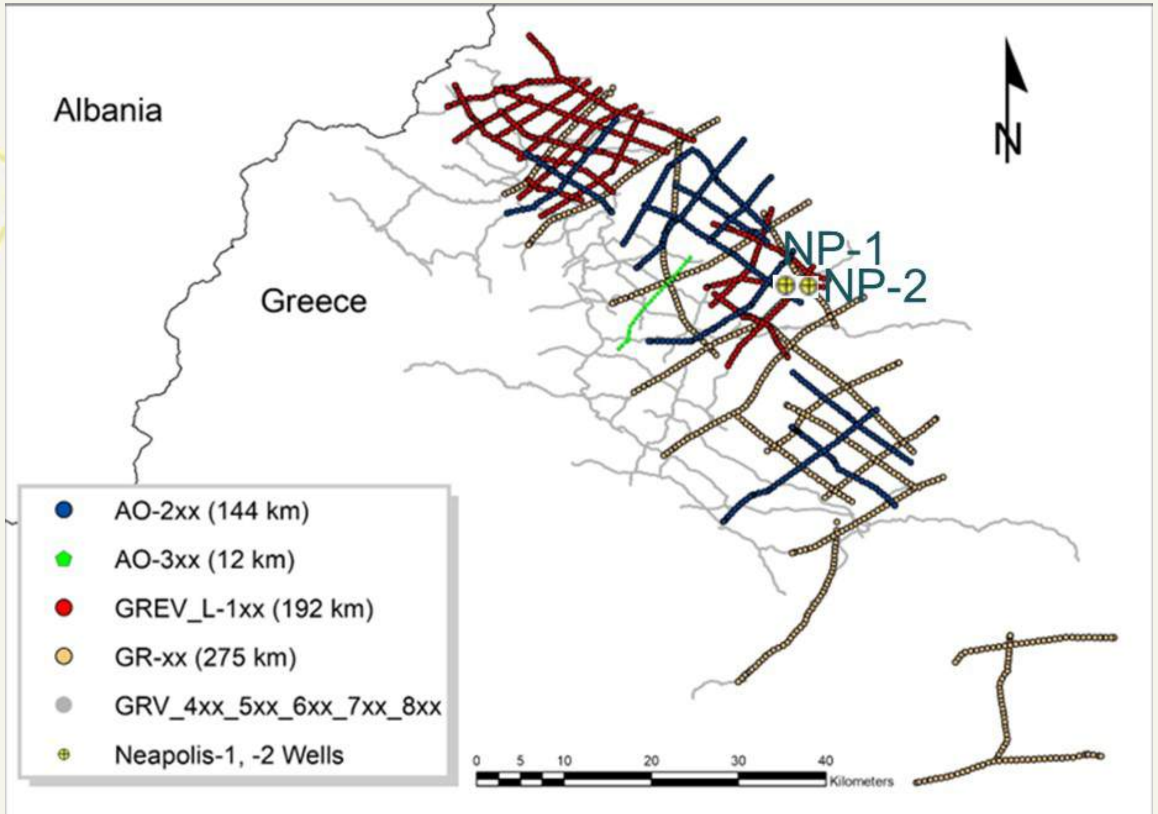
Active but stable deep-fluid system; no geochemical barriers to CO_2 injection and long-term containment.

Table 8.19: Targeted Gas chemical analysis as a result of the fourth water sampling campaign

Spring location	Katakali	Kivotos	Tropeouhos	Neos Kafkasos	Katakali-2	Kivotos-2	Tropeouhos-2	Plank (bottled water)
He (ppm)	-	43	-	10	-	44	1.4	-
H2 (ppm)	-	-	-	-	-	-	-	-
O2 (%)	0.12	0.19	0.21	0.58	0.1	0.24	0.21	3.3
N2 (%)	4.07	19.08	22.56	8.45	6.08	20.04	22.47	19.86
CH4 (ppm)*	300370	43000	81	7	312300	44100	81	2.7
CO* (ppm)								19.5
CO2* (%)	2.33	1.67	2.4	49.9	2.44	1.73	2.49	0.94
Gas volume (cc per 120 cc of sample)	7.4	6.2	6	10	7.6	5.8	5	5.6
He (×10−4 cc L-1 STP)	0.0	27.9	0.0	9.8	0.0	27.0	0.9	0.0
H2 (cc L-1 STP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O2 (cc L-1 STP)	0.10	0.14	0.15	0.62	0.09	0.17	0.15	2.26
N2 (cc L-1 STP)	4.19	17.63	20.44	10.65	6.37	17.81	20.36	17.29
CH4 (×10⁻3 cc L-1 STP)	14558.3	1833	4.0	3.3	15440.5	1903.3	4.04	0.1
CO (×10⁻3 cc L-1 STP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
CO2 (cc L-1 STP)	26.90	19.10	27.40	587.10	28.20	19.70	28.40	10.70
total Alk	15.8	6.3	2.00	4.2	15.7	6.4	2.1	4.0
d13CTDC	13.9	-14.2	3.9	-1.2	14.4	-15.8	1.9	-11.2
d13CCH4	-69.5	-75.5	-	-	-69.8	-69.5	-	-
dDCH4	-251	-107	-	-	-230	-92	-	-

Tyrologou, P., et al.,(2025) Investigative research for occurrences of hydrogen, helium, methane and carbon dioxide in West Macedonia: linking geological reservoirs to subsurface gas generation and migration.

Legacy Data & Modern Reprocessing Workflow



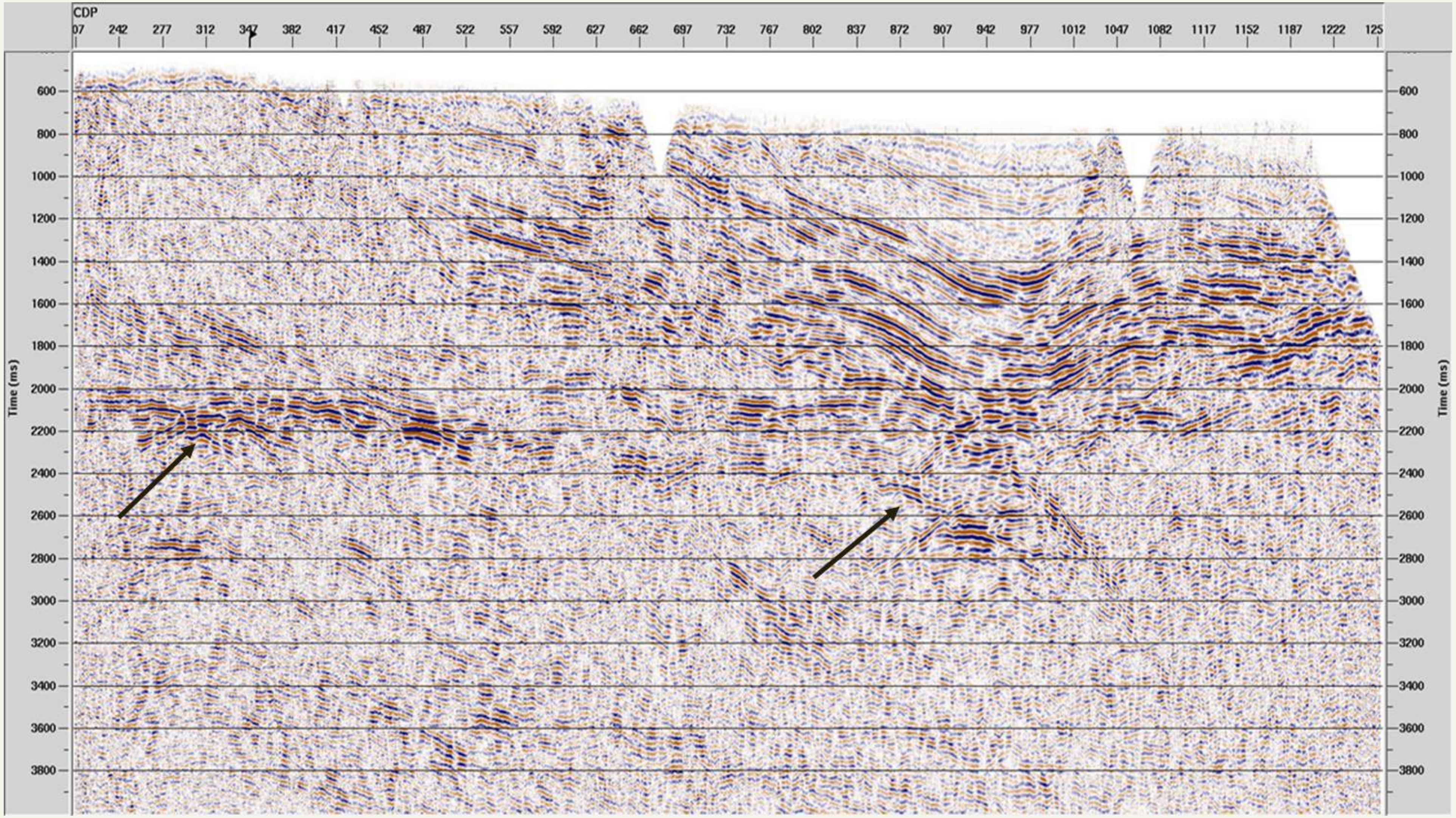
- **1980–1984:** ~623 km of 2D seismic (GR, L, AO) acquired using **dynamite sources**
- **1991–1994:** ~662 km of 2D seismic (GRV) acquired using **vibroseis technology**
- **1967: Neapolis-1 (NP-1)** and **Neapolis-2 (NP-2)**
- Well logs available (GR, Sonic, Resistivity)
- Penetrated **Tsotyli Fm (marls & sandstones)**
- **Reservoir not encountered at drilled depths**

➢ ***These legacy datasets formed the foundation for modern reprocessing and updated basin-scale interpretation.***

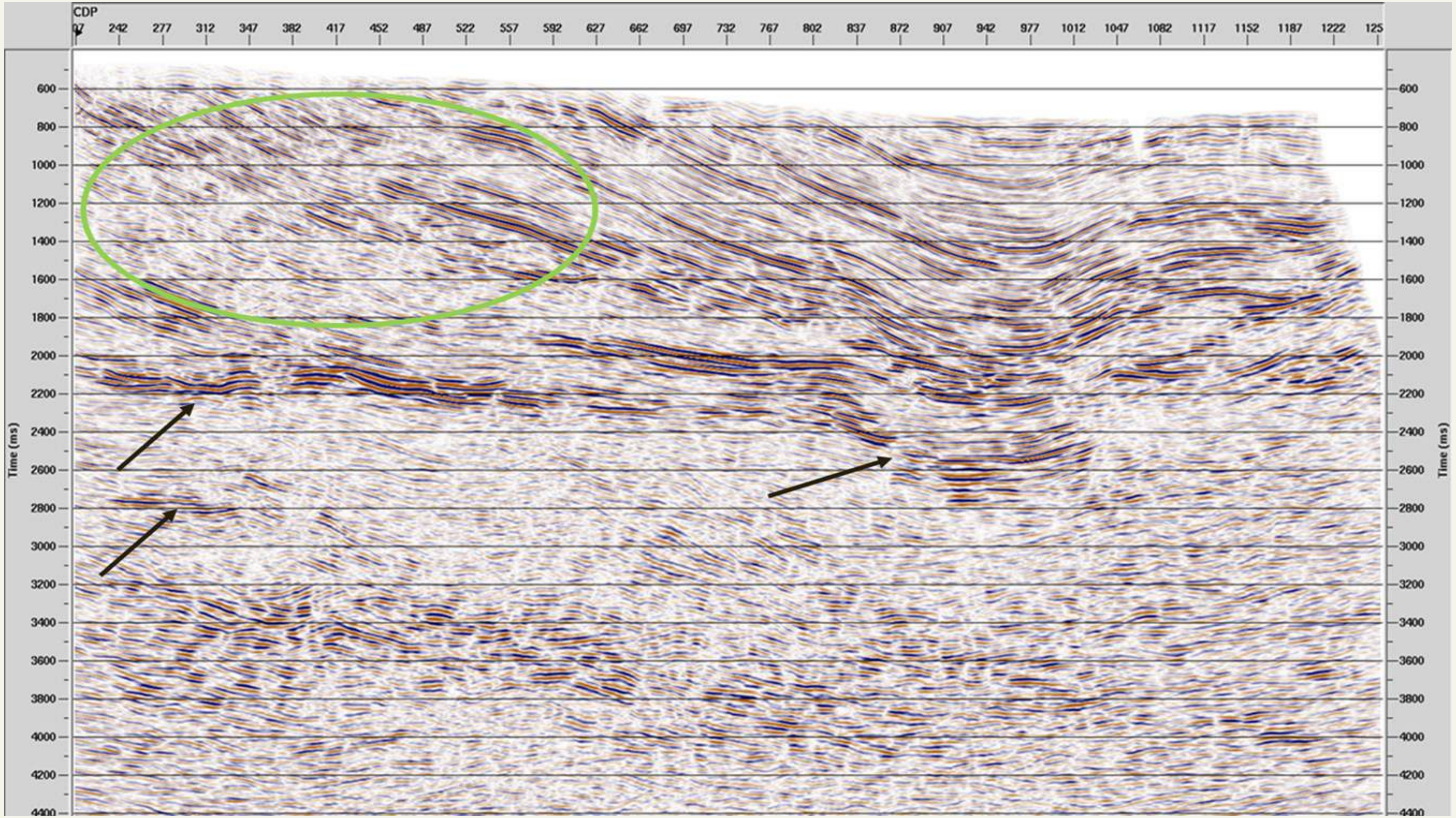
Modern reprocessing workflow (PSTM-based)

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	
Geometry loading and Pre-Processing	Signal Processing and Denoise	Static Correction and Velocity Analysis	Demultiple and Interpolation	Stack and Post-Stack Time Migration	Kirchhoff PreSTM	Products Delivery
✓	✓	✓	✓	✓	✓	✓

Legacy Brute stack – Line GRV-818 (90s)

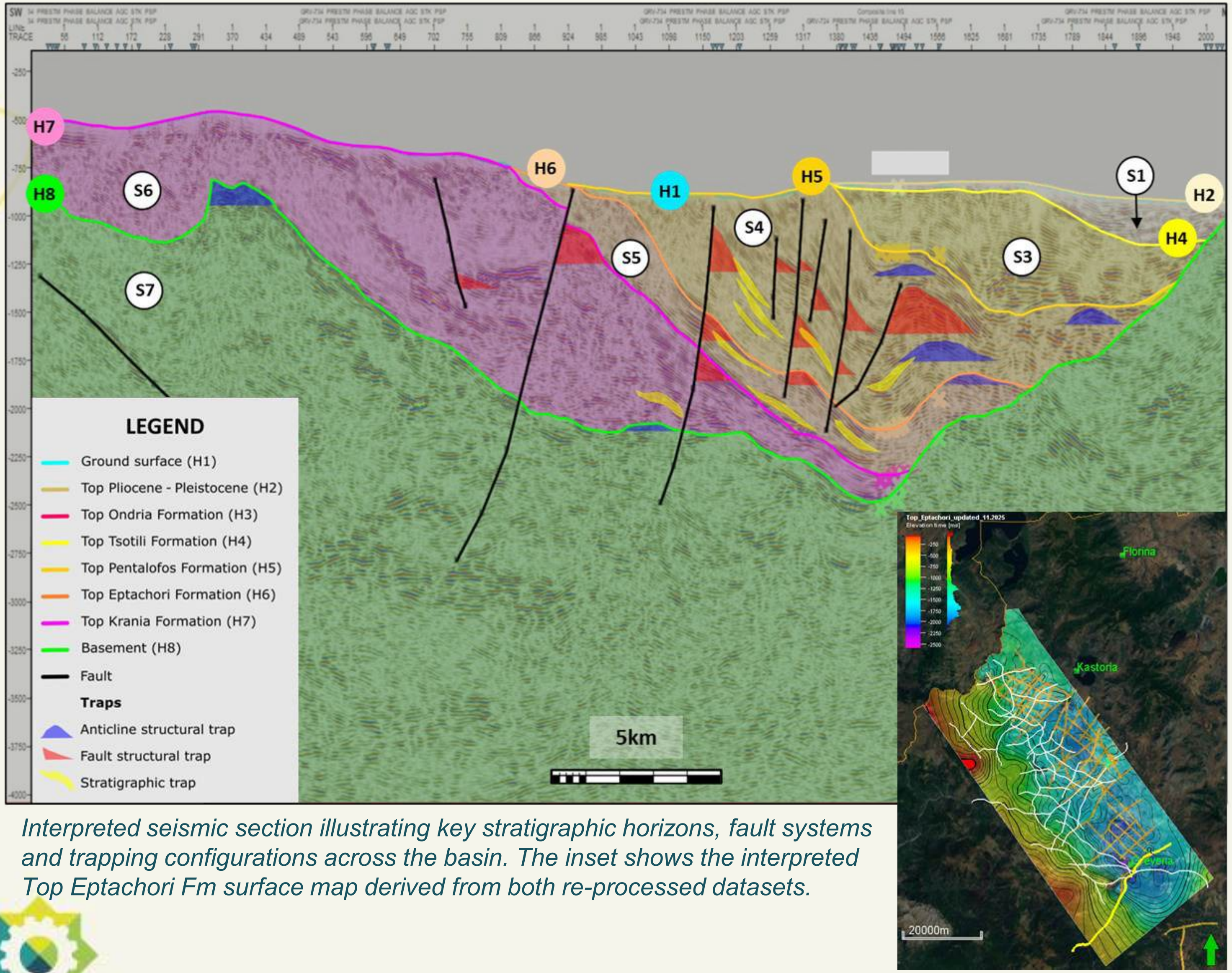


Final PreSTM with Phase Balancing – Line GRV-818 (New Processing)



➢ Significant improvement in reflector continuity and fault imaging

Seismic Interpretation & Storage Trapping Mechanisms



Interpreted seismic section illustrating key stratigraphic horizons, fault systems and trapping configurations across the basin. The inset shows the interpreted Top Eptachori Fm surface map derived from both re-processed datasets.

Key Insights
- Improved imaging of major horizons
- Fault systems controlling basin structure
- Identification of trapping configurations

Structural Traps
- Anticlinal structures (1–2.5 km width, <500 m relief)
- Mainly developed within S7–S4 sequences
- Locally combined with stratigraphic trapping

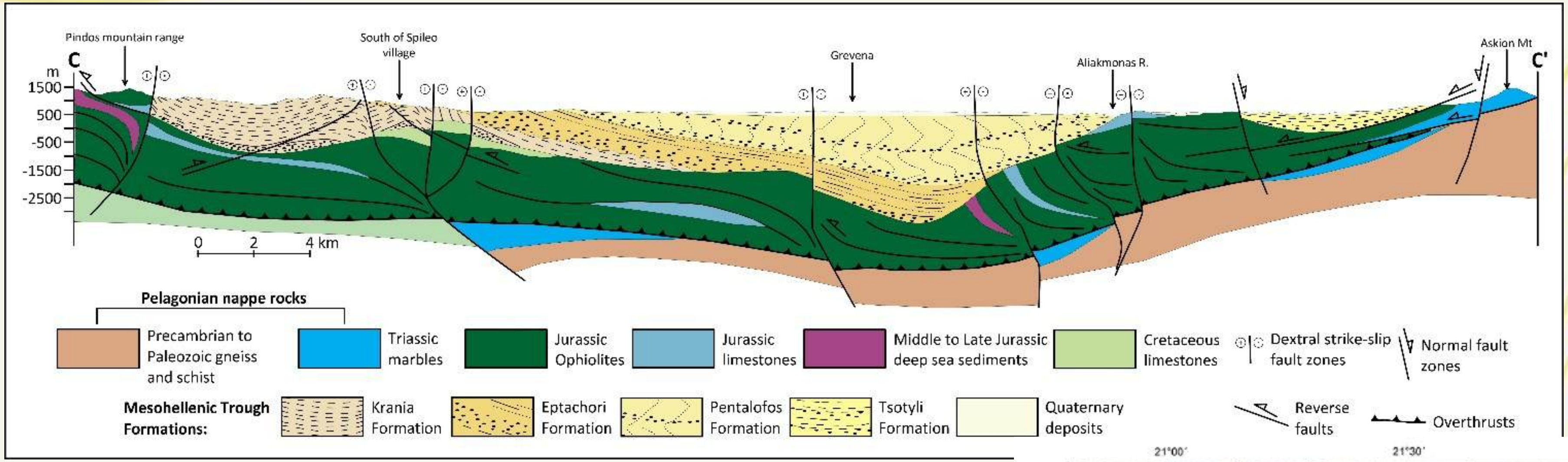
Fault-related Traps
- Frequent across the basin
- Typically small-scale, linked to normal faulting
- Control fluid migration pathways

Stratigraphic Traps
- Channelized turbidites and pinch-outs
- Laterally extensive and often stacked
- Commonly associated with structural elements

Geological conceptual model

Overview

- Integrated interpretation of stratigraphy, structural architecture and geochemical indicators defining the CO_2 storage system of the Mesohellenic Trough.
- The basin is organised in stacked reservoir–seal pairs controlled by lithology and regional tectonic structure.



Key elements

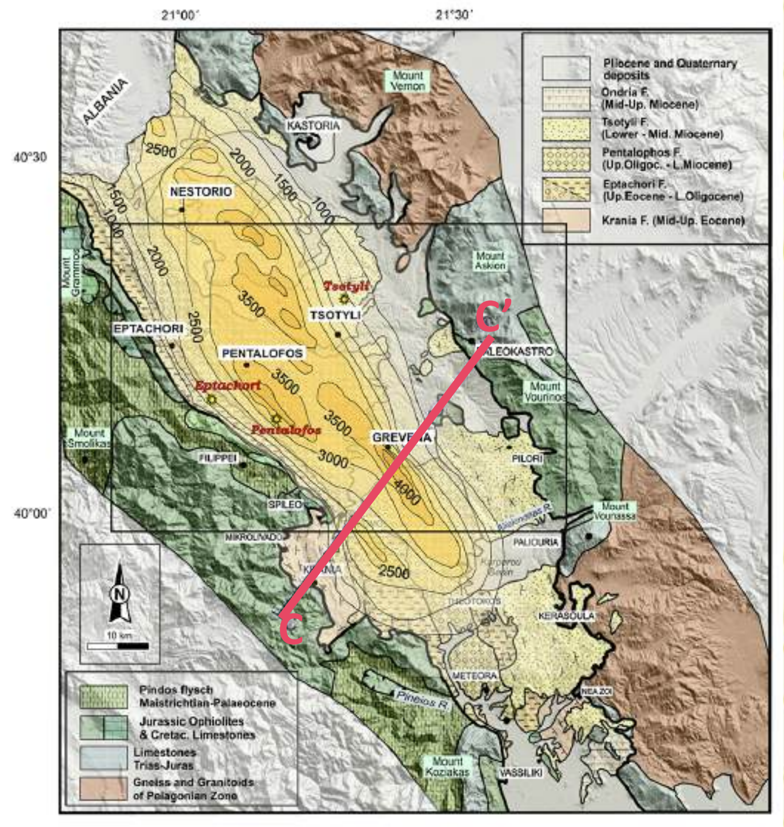
- **Reservoirs:** Eptachori & Pentalofos Fm – sandstones/conglomerates with measured porosity values up to ~10.8%. Laterally extensive stratigraphic bodies suitable for storage intervals.
- **Seal**: Tsotyli Fm – marl-rich, very low permeability, regionally continuous caprock units providing effective sealing potential.
- **Structural framework**: Gently dipping basin architecture with limited large-scale faults. Faults locally act as fluid migration pathways but also as structural traps.
- **Gases (CH_4, H_2, He):** confirm an active deep-fluid system.

Outcome

Multi-layered system with:

- reservoir–seal stratigraphic stacking
- defined structural control
- evidence of natural gas migration and potential trapping

Geologically favourable conditions for CO2 storage in Mesohellenic Trough



Key Geological Uncertainties & Future investigation needs

Subsurface structural architecture

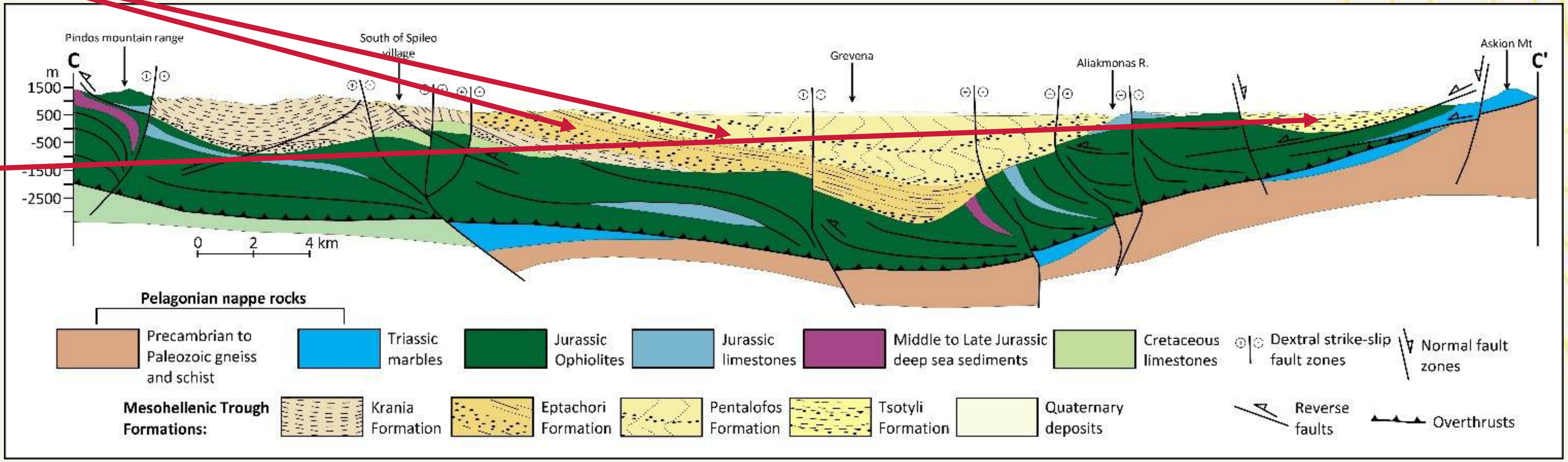
- Current interpretation relies partly on legacy seismic datasets
- Higher-resolution seismic data required to refine trap geometry and reservoir distribution

Reservoir heterogeneity

- Lateral and vertical variability of sandstone bodies within the Eptachori and Pentalofos formations
- Influence on effective storage capacity and injectivity

Seal continuity & integrity

- Spatial variability of marl-rich sealing intervals of the Tsotyli formation
- Need to verify caprock thickness, continuity, and sealing capacity at depth



Fault-controlled fluid migration

- Faults may locally act as migration pathways
- Detailed assessment required to determine whether they function as barriers or conduits

Reservoir pressure & injectivity

- Limited data on deep reservoir pressure conditions
- Additional studies required to evaluate CO2 injectivity and pressure evolution during storage

Role of the Mesohellenic Trough in the European CCS landscape

- South-Eastern Europe remains underrepresented in geological CO_2 storage sites
- Greece is advancing CCS deployment, with the Prinos CO_2 storage project progressing towards implementation
- Western Macedonia could contribute to regional CCS capacity/ Western Macedonia offers a complementary onshore storage option to support a national CCS portfolio
- Former lignite region undergoing rapid decarbonisation
- Opportunity to transform existing energy infrastructure towards carbon management
- Potential to support industrial decarbonisation
- Strengthening the European CO_2 storage network
- Contribution to regional CO_2 storage capacity and cross-border CO_2 transport networks
- Overall, this work upgrades the Mesohellenic Basin from a screening-level candidate to an appraisal-ready CO_2 storage prospect

From Geological Knowledge to Climate Solutions

Key outcomes

- Integrated geological investigations significantly improved the understanding of the Mesohellenic Trough basin system
- Stratigraphy, structural framework and geochemical indicators support the existence of a multi-layered reservoir–seal architecture / system
- The basin shows promising geological conditions for safe and effective CO_2 storage

Pathway forward

1. Refinement of subsurface structural models
2. Improved assessment of reservoir properties and storage capacity
3. Development of a site-specific CO_2 storage concept

PilotSTRATEGY

Acknowledgements

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

Project impact and way forward in Upper Silesia - Poland

Project General Assembly, Brussels, April 2026

Krzysztof Stańczyk, Anna Śliwińska, Aleksandra Koteras,
Tomasz Urych, Aleksandra Strugała-Wilczek, Fernanda Veloso*,
GIG-PIB, *Cquestra

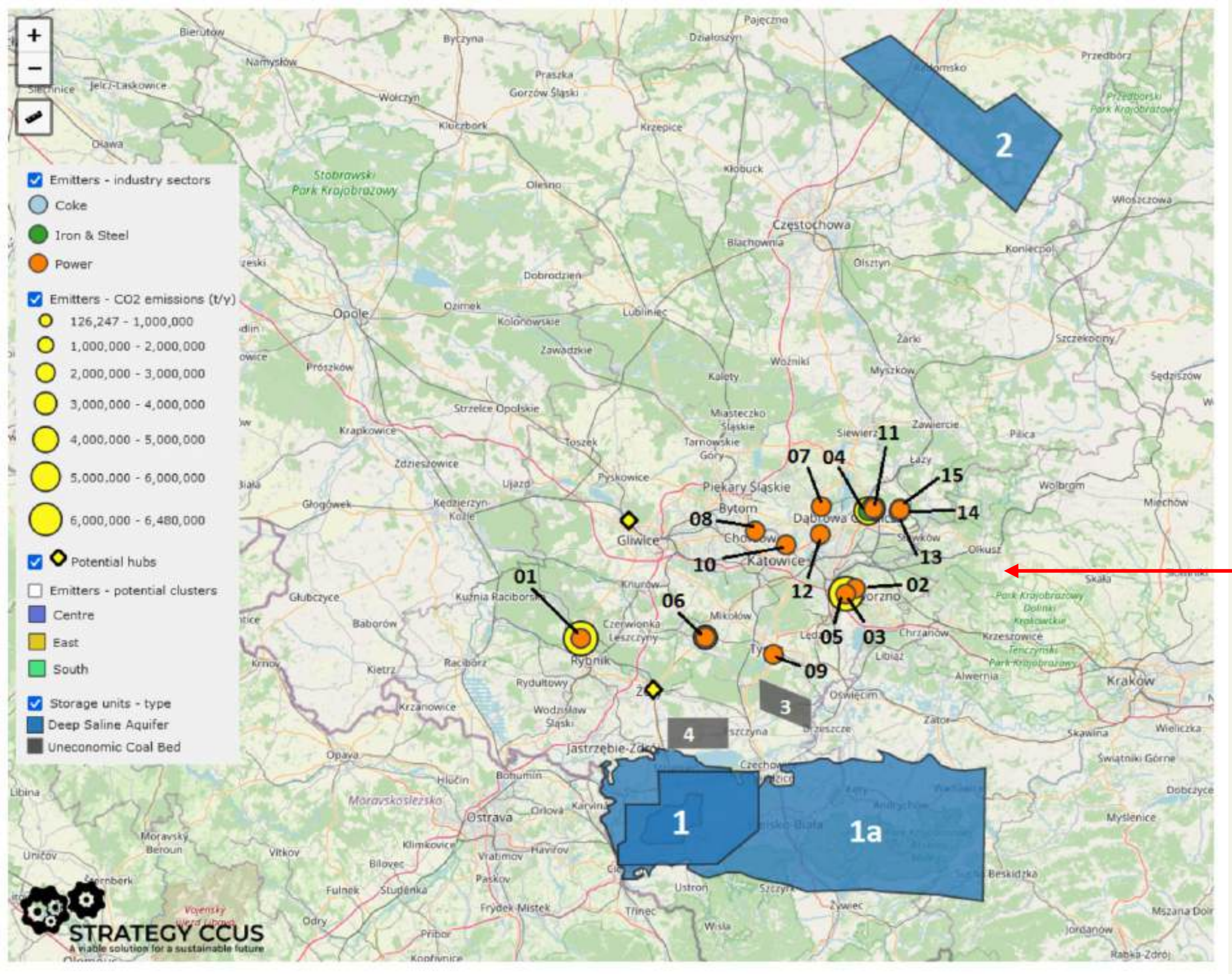
The PilotSTRATEGY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022664

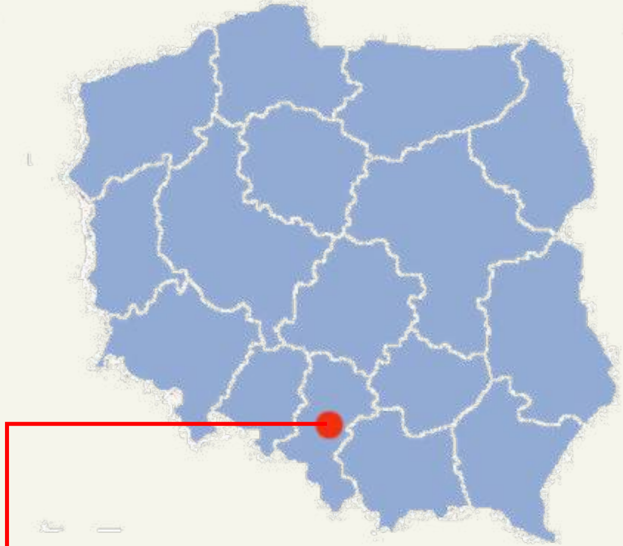
Presentation schema

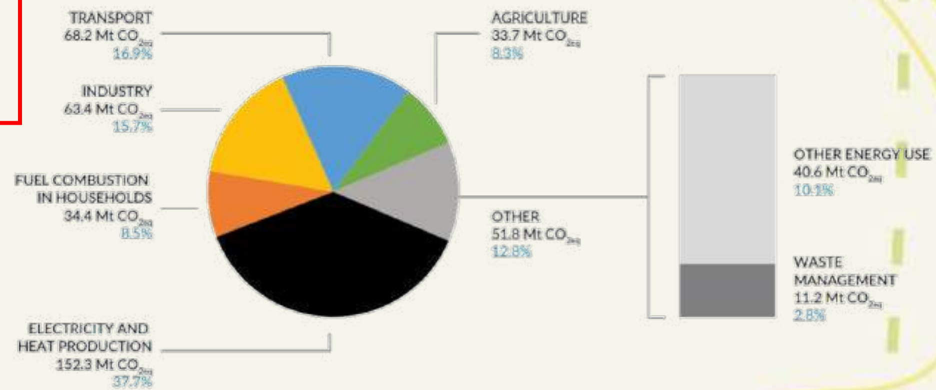
- **Project impact - main findings:**
  - **Technical results**
  - **Social results**

- **Way forward in Upper Silesia**
  - **Project Ładzice CO2**

Geographical location of Upper Silesia Coal Basin and potential emitters of CO2







Structure of greenhouse gas emissions in Poland (2025)
Energy Transition in Poland 2025 Edition,
Energy Forum 2025

Upper Silesia, Poland

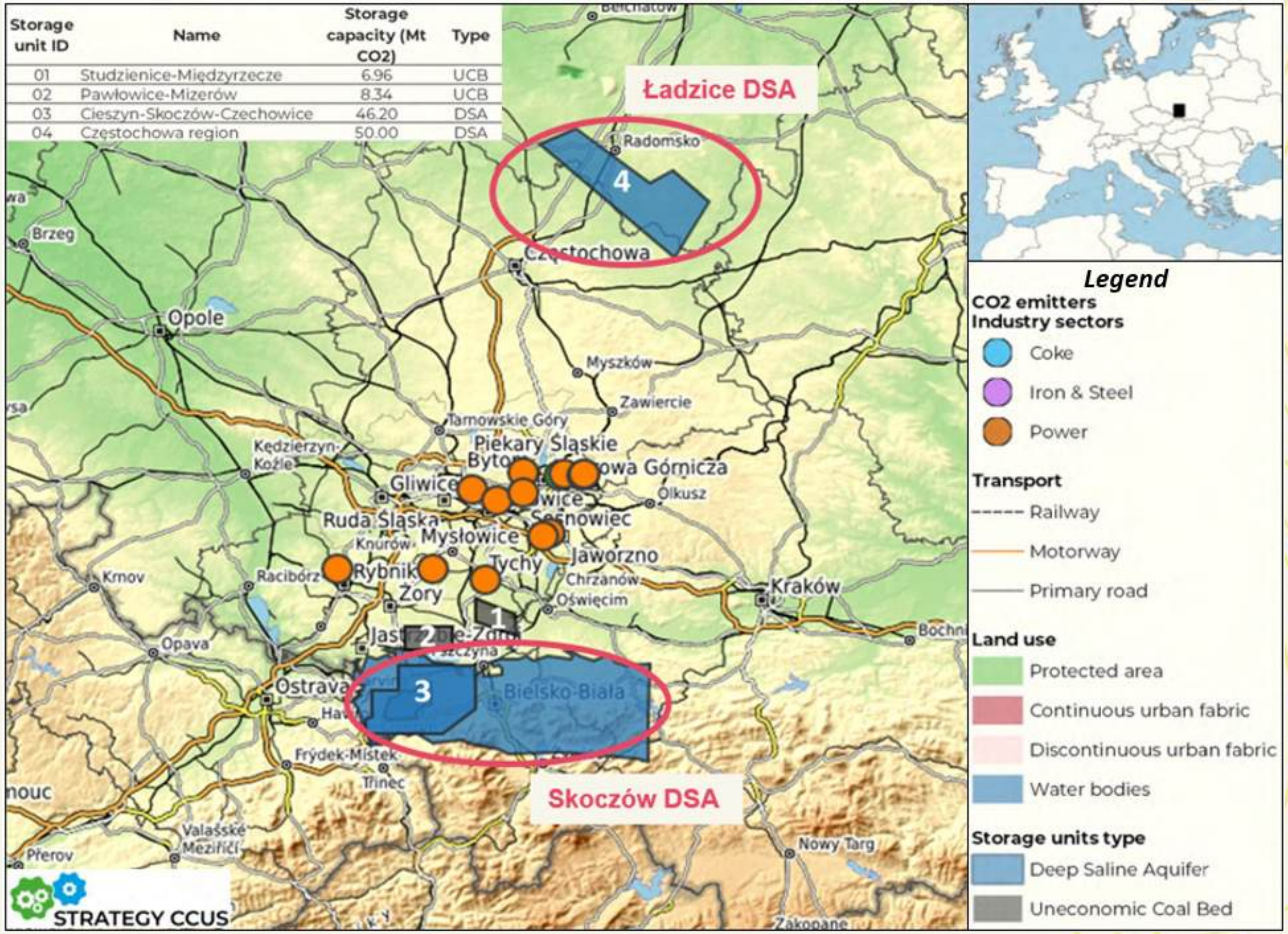
Location and storage potential of the region

Two possible storage places have been identified in the region in deep saline aquifers:

- Skoczów DSA - Upper Silesian Coal Basin,
- Ładzice DSA - Jurassic Czestochowa District.

Potential CO_2 storage capacity of 0.1 Gt in DSA, about 50 mln tons in each region.

According to the planned Polish regulations, only in the region Ładzice the storage will be allowed.

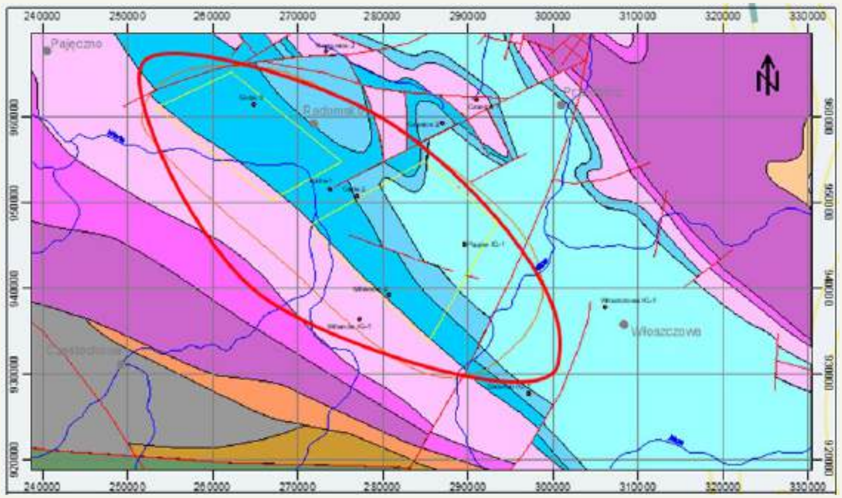


Storage unit ID	Name	Storage capacity (Mt CO2)	Type
01	Studzienice-Międzyrzecze	6.96	UCB
02	Pawłowice-Mizerów	8.34	UCB
03	Cieszyn-Skoczów-Czechowice	46.20	DSA
04	Częstochowa region	50.00	DSA

WP2: Geo-characterisation of Jurassic Częstochowa District (Ładzice DSA)

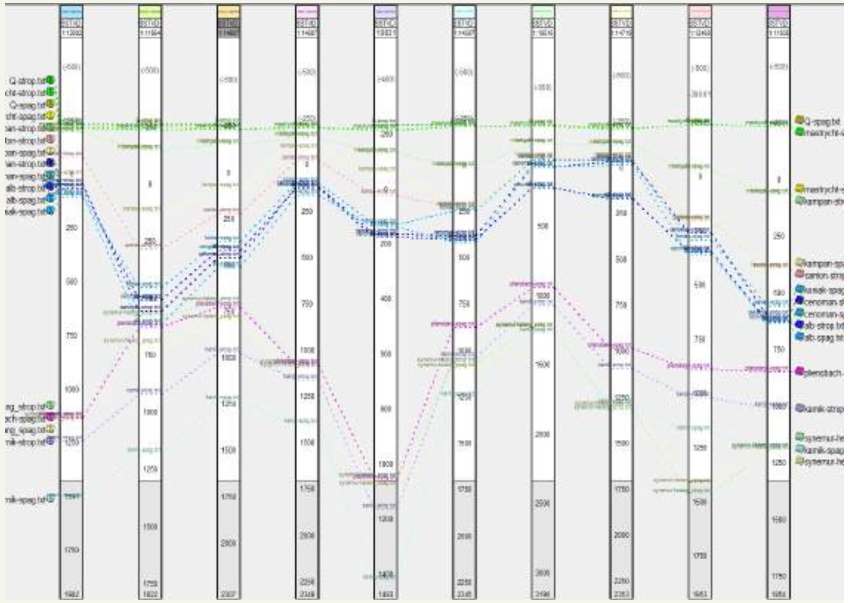
1. REGIONAL GEOLOGY OF SEDIMENTARY BASINS

This place, about 80 km away from the main emitters, is treated as the second possible option for CO_2 storage in the Upper Silesia region.
Reservoir formations are associated with water-saturated sediments of the Lower Jurassic and the lower stages of the Middle Jurassic. The aquifer is made up of sandstones with a fine- to coarse-grained structure, as well as sandstones of various grains.



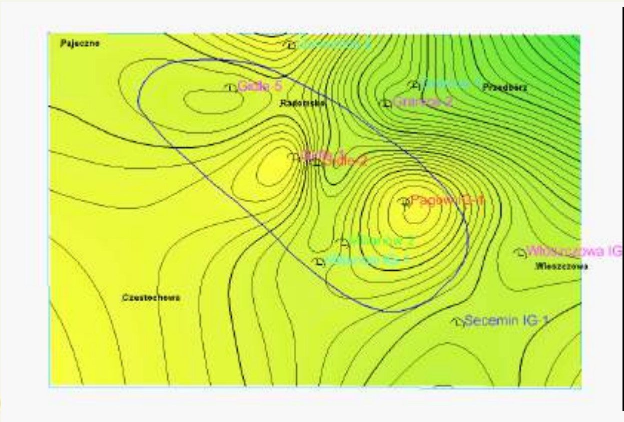
2. WELL DATA ANALYSIS

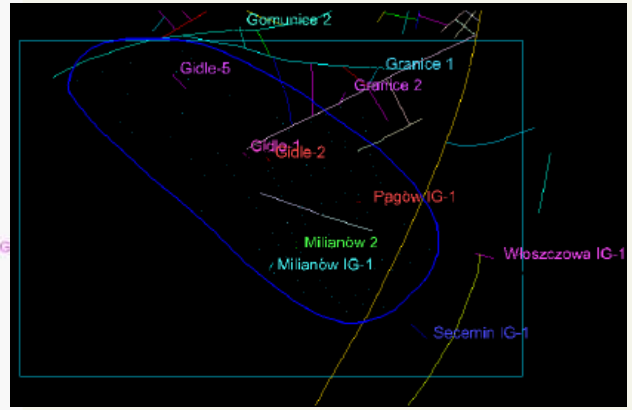
Compilation of additional well data: lithologies in 10 boreholes, petrophysical data: porosity (effective), permeability. Works included preparing data regarding parameters of reservoir fluids such as properties of reservoir water, mineralization and others in order to provide inputs for reservoir modeling.

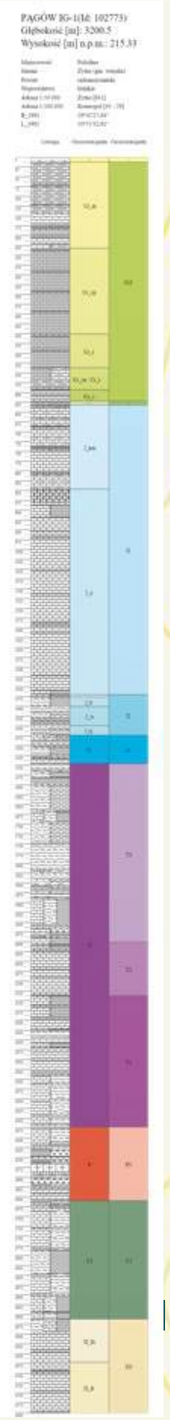


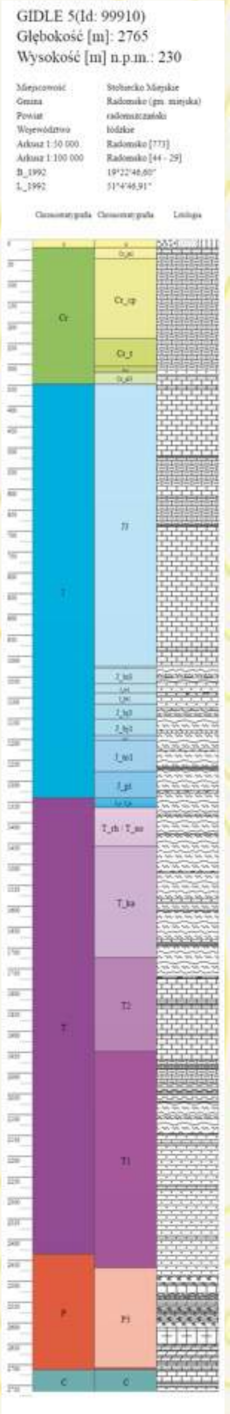
3. ELEMENTS OF GEOLOGICAL CONCEPTUAL MODELS

Development of structural surfaces in the area of the Jurassic Częstochowa District/Ładzice DSA reservoir including depth, thickness and structural framework of the selected area of reservoir deposits (maps of top and base of reservoir layers)







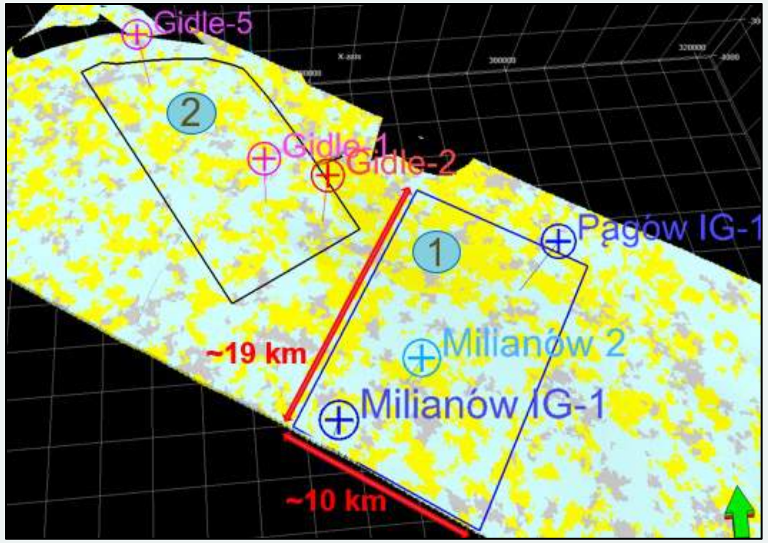


CONSTRUCTION OF GEOLOGICAL GRID

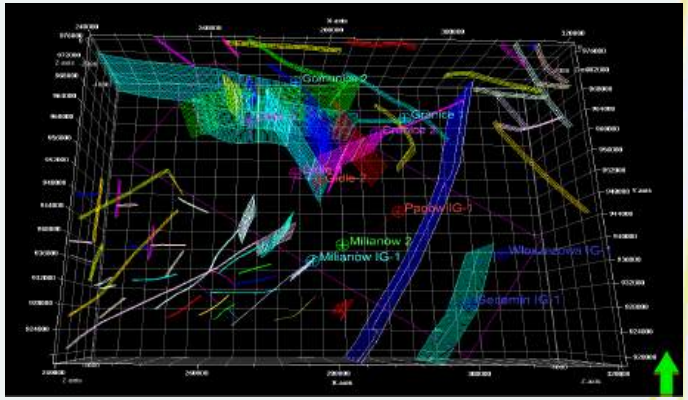
Jurassic Czestochowa District (Ładzice DSA)

- Fault model was built based on the results obtained from WP2 Geo-characterization including geological maps, cross-sections and other data.
- Location of part of faults are confirmed but part of faults are only hypothetical (supposed) but we implemented it for the purposes of uncertainty and risk analysis.
- Location, range and grid orientation were assumed. The dimensions of the model are as follows: the length is about 62 km and the width is about 24 km.

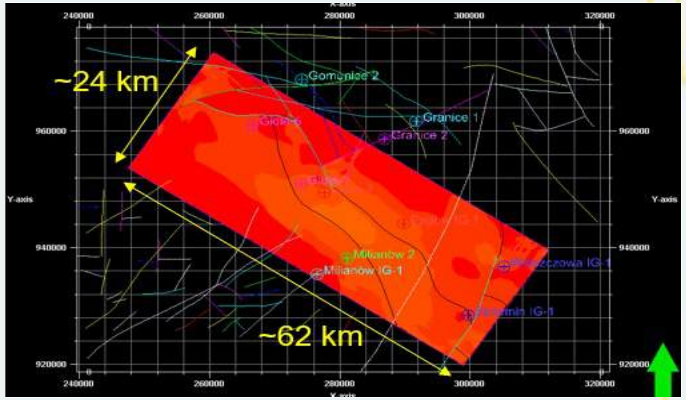
- Two potential areas have been identified,
- Selected only the area No. 1 (10 km x 19 km),
- Model of the storage complex zone (structural model, facies model),
- Petrophysical modelling (porosity, permeability).



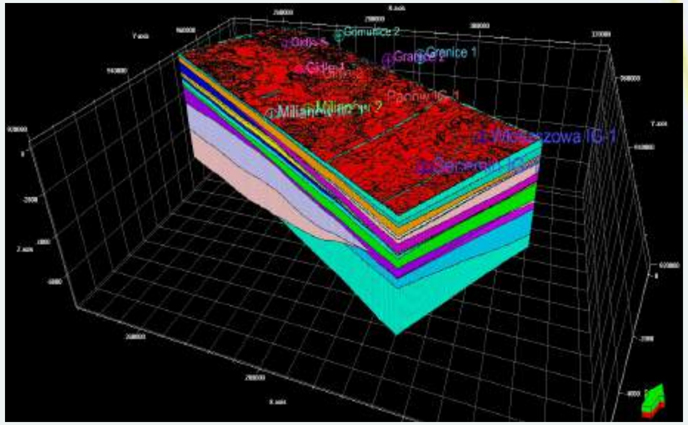
Two potential storage areas indicated based on analysis of data availability



Fault and fracture model



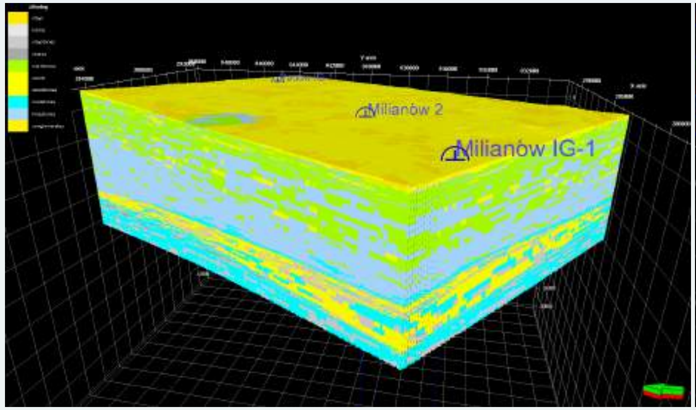
Location, range and grid orientation of the model

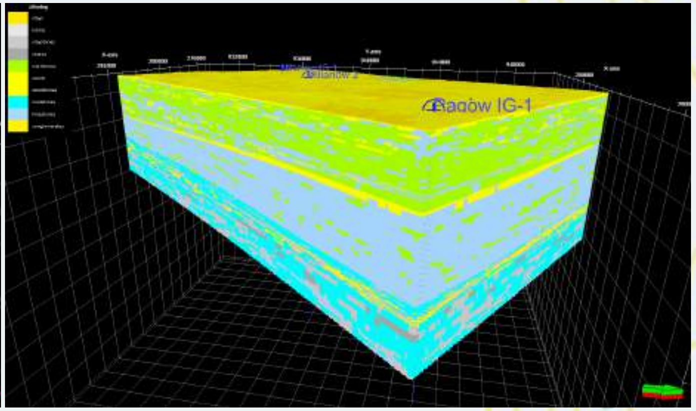


The model of reservoir layers
with the overburden and underburden of the reservoir

PROPERTY MODELLING

Jurassic Czestochowa District (Ładzice DSA)



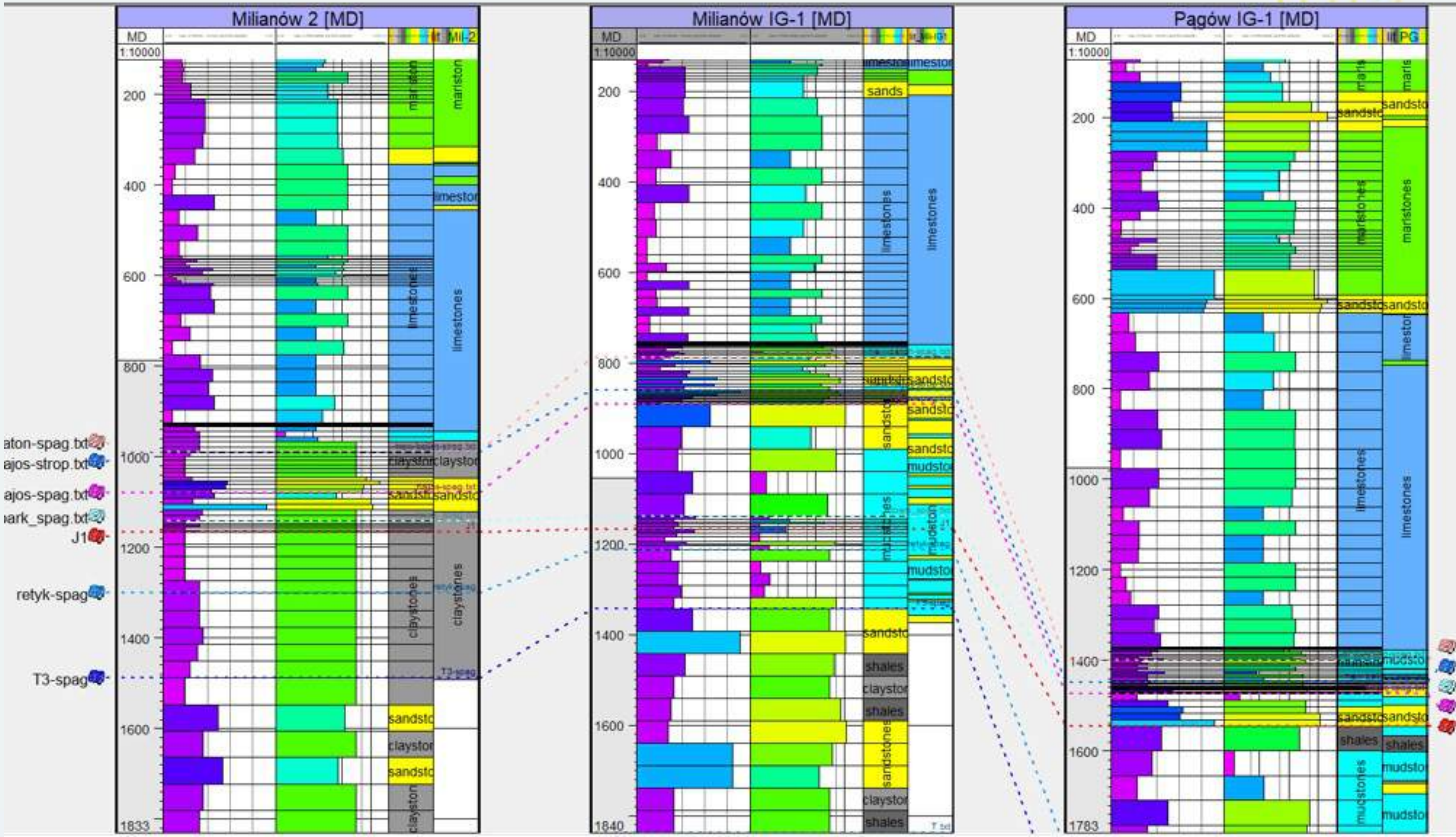


- Facies model of the storage complex for selected area (reservoir and overburden with sealing layers)

- Petrophysical modelling (porosity, permeability) for the overburden and the reservoir layer

- Thickness of the reservoir layer: ~ 50 m (Lower Jurassic and the Lower Middle Jurassic - J1/J2 sandstones);
- porosity from 7.69 to 22.1%;
- permeability from 16 to 1478 mD.
- High values of permeability of **reservoir** are observed in two wells:

- Pągów IG-1 (837 mD, 1478 mD),
- Milianów IG-1 (931mD, 1230mD, 1320mD)



Petrophysical modelling

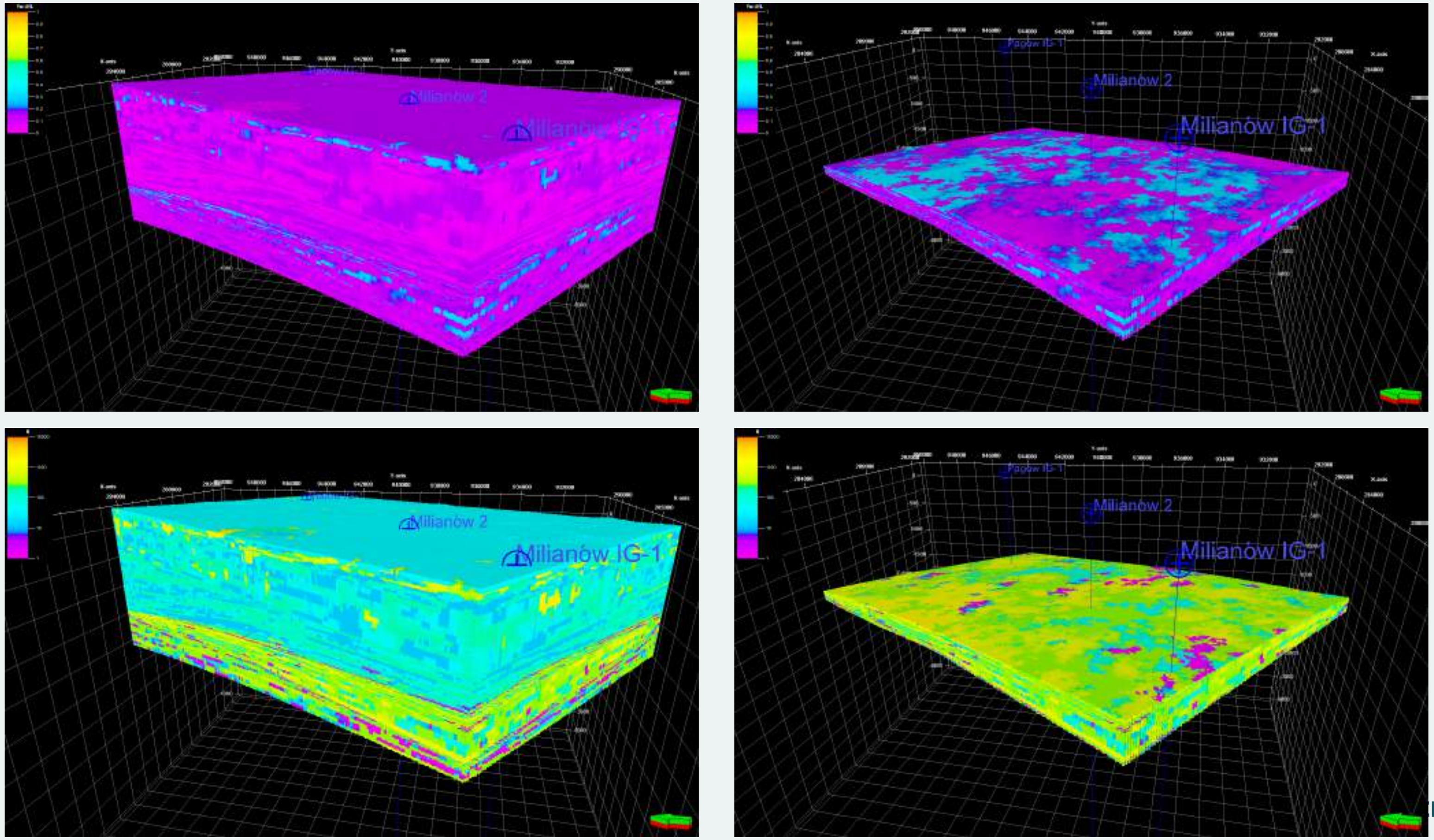
Jurassic Czestochowa District (Ładzice DSA)

In the case of Ładzice DSA there were observed lack of VShale (shale volume) data in log files (available only porosity and permeability). The created facies model was used as conditioning for the petrophysical model.
Modelling of porosity and permeability was performed using Sequential Gaussian Simulation (SGS) algorithm separately for individual sequences using the control procedure of the previously developed lithological model (petrophysical properties linked to lithofacies).

Porosity model

Permeability model

The results of petrophysical modeling of **the reservoir layer with the overburden.**



The results of petrophysical modeling of the **reservoir layer**.

The output of this task for the model of Ładzice DSA are the following properties: facies, porosity and permeability.

Dynamic modelling and optimization

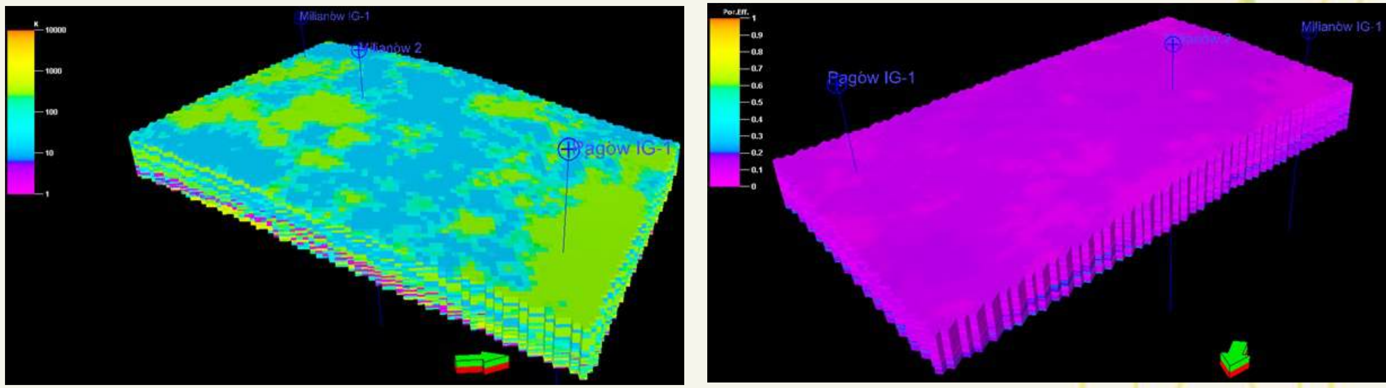
Jurassic Czestochowa District (Ładzice DSA)

This step of the work covers storage capacity assessment by simulation, based on well locations and flow rate optimization. The optimization should maximize the potential capacity by taking into account the uncertainties in properties of geological model.

The preliminary location of injection wells was selected manually based on properties of geological model, flow properties, pressure perturbation and operational constraints. Based on preliminary visual and statistical analysis, the following injection wells: IN-1A, IN-5A, IN-6 can be assumed as the pilot-scale injection wells with injection rate ~300 kt/year.

The primary objective of task 3.2 is to define the location for a pilot-scale injection well.

Well	Flow rate [sm³/day]	Flow rate [kt/year]	Injection time [years]	Gas injection volume [Mt]	Max. BHP [bar]
IN-1A	439 761	300	10	3	165
IN-5A	439 761	300	10	3	165
IN-6	439 761	300	10	3	165



Stochastic realization of permeability and porosity closest to P50 model of pore volume
- upscaled model with surface dimensions of 200 × 200 m (173,200 cells)

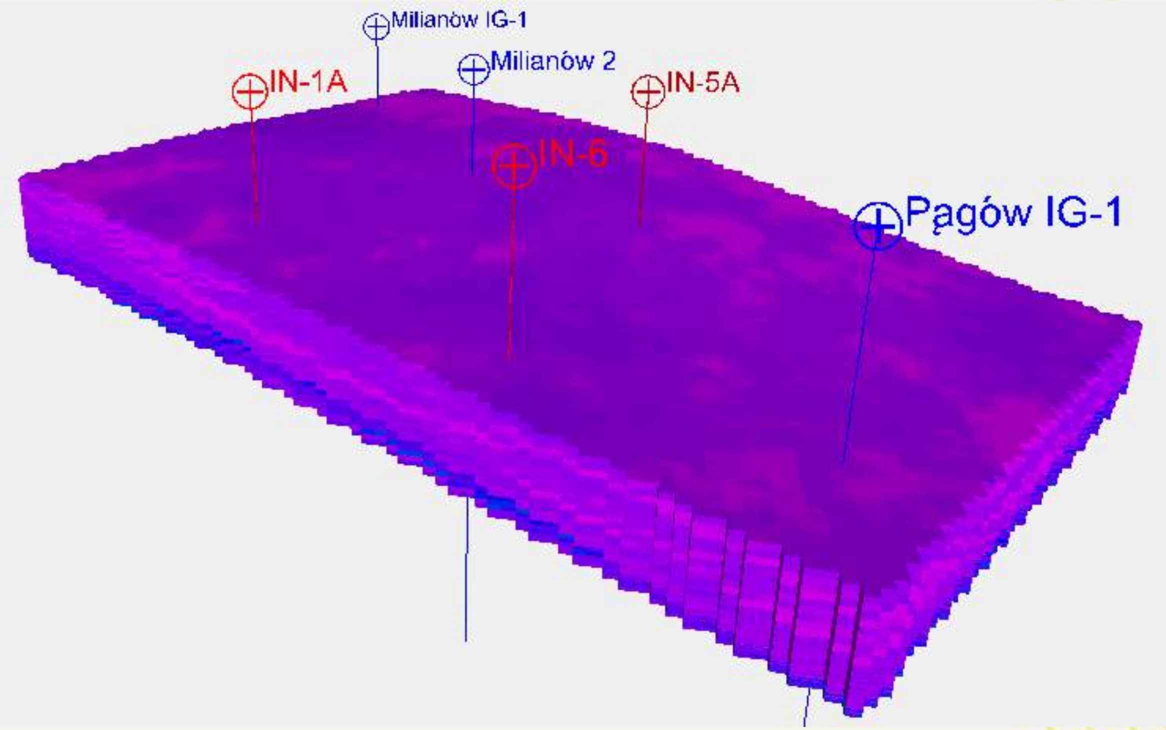


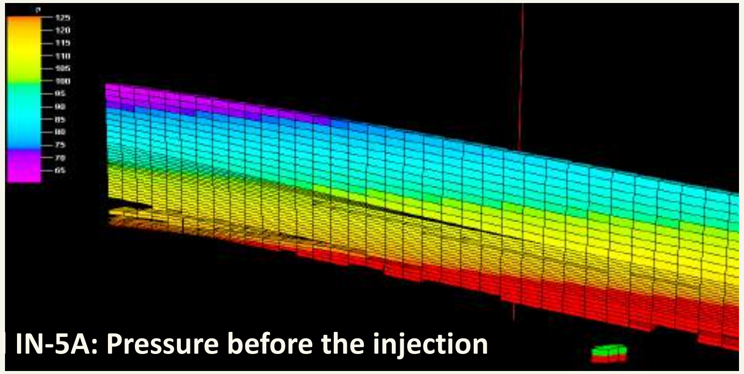
Fig. Three potential locations for a pilot-scale injection well in the model

Dynamic modelling and optimization

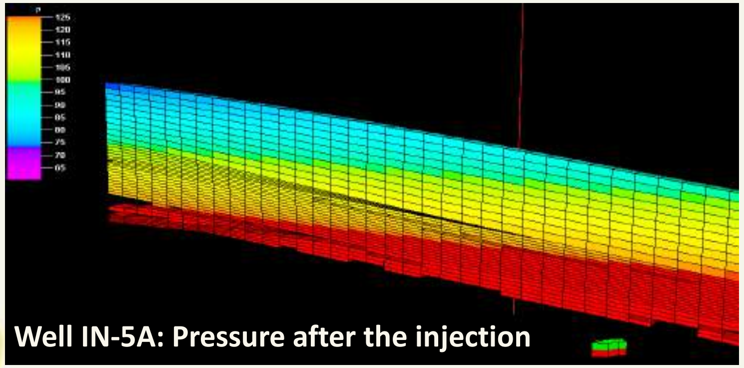
Jurassic Czestochowa District (Ładzice DSA) - Poland

- **Analysis of flow rates**

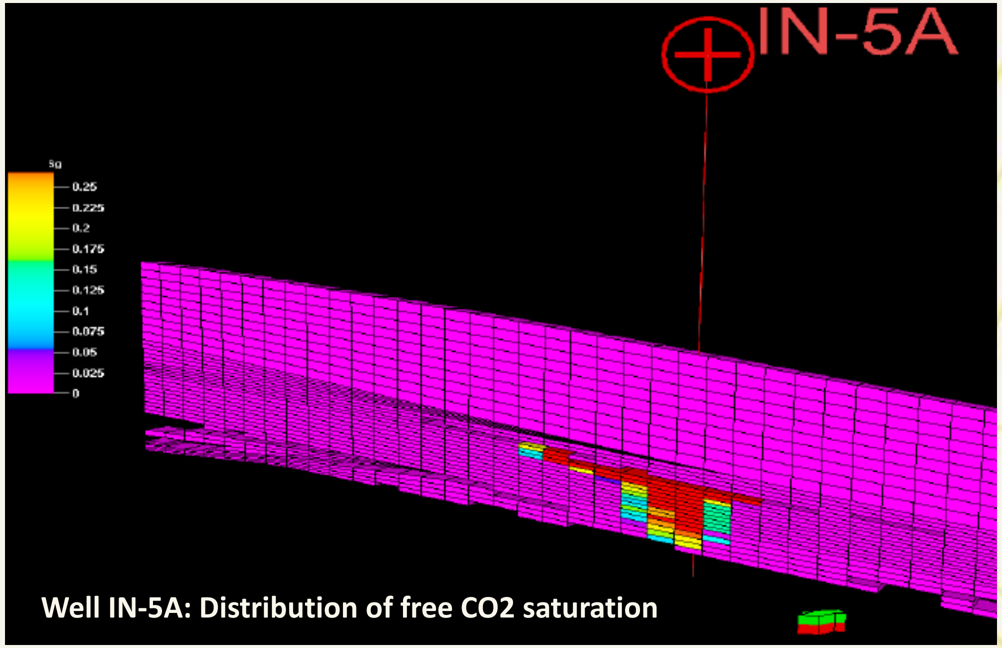
Preliminary location of three injection wells were selected based on properties of geological model and the results of preliminary numerical simulations. An increase in average pressure in the injection zone to acceptable values was observed. It was stated that based on preliminary analysis, three analyzed injection wells with a CO_2 injection rate approximately 300 kt/year for 10 years can be considered as the pilot-scale injection wells.



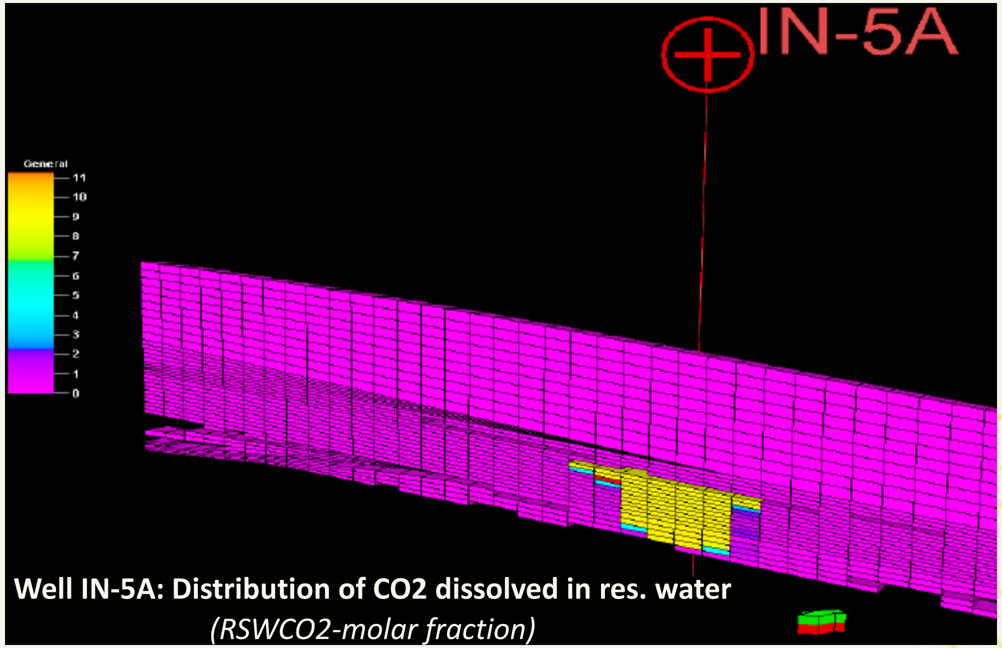
IN-5A: Pressure before the injection



Well IN-5A: Pressure after the injection



Well IN-5A: Distribution of free CO2 saturation



Well IN-5A: Distribution of CO2 dissolved in res. water

(RSWCO2-molar fraction)

Assessment of the storage capacity by simulations

Jurassic Czestochowa District (Ładzice DSA)

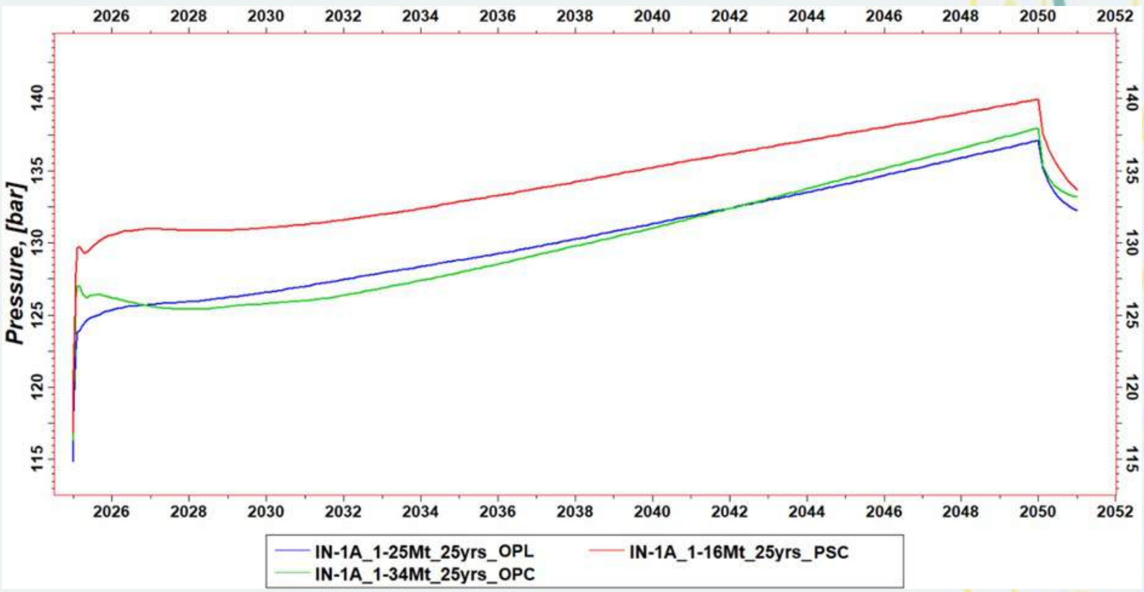
Optimization of well location based on analysis of flow responses to the CO_2 injection (plume migration & pressure perturbation)

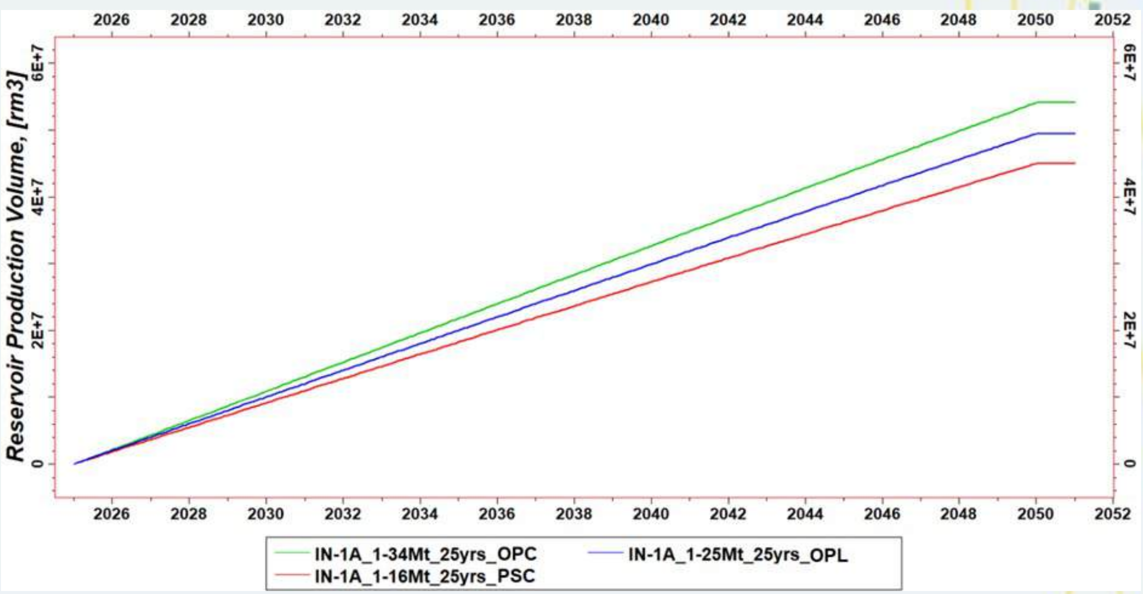
- **maximise the CO_2 injection rate taking into account the max increase of pressure;**

Based on the fluid flow simulations, the output value of the CO_2 amount possible to be injected was estimated. The maximum value of flow rate for injection well IN-1A amounts to 1.25 Mt/year which give the maximum potential CO_2 storage capacity about 31.25 Mt within 25 years in optimal scenario of the geological model. In the case of the IN-5 and IN-6 wells, much lower values of injection rates and, consequently, low values of maximum potential storage capacity were observed.

Well name/ Model	Max. flow rate [Mt/yr]	Max. potential capacity [Mt] (injection time = 25 years)	Scenario	Remarks
IN-1A	1.16	29.00	pessimistic	Max. overpressure in the top of reservoir layer = 20%
	1.25	31.25	optimal	
	1.34	33.50	optimistic	

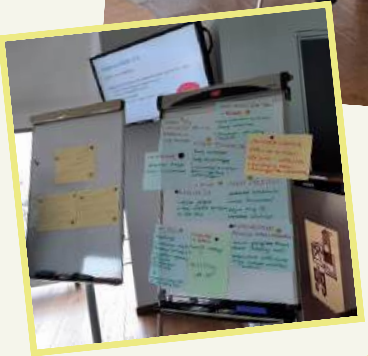
Results of simulations for CO_2 injection period of 25 years





WP6: Regional Stakeholder Committee workshops

- The 1st RSC workshops took place in Katowice (Upper Silesia, Poland) on the 5th of October 2023.
- The 2nd RSC workshops took place in Katowice (Upper Silesia, Poland) on the 14th of January 2026.
- Stakeholders represented various branches (industry, public administration, local authorities, policy makers, civil society organizations and scientific community).
    - Presentations about:
        - the Pilot STRATEGY project updates,
        - a short summary of the results regarding social acceptance and the survey results,
        - determining the CO_2 storage potential in the region – the current status of key research for planning the CCS pilot in Poland,
        - the current legal status of CC(U)S in Poland.
    - Discussion and workshops in subgroups.



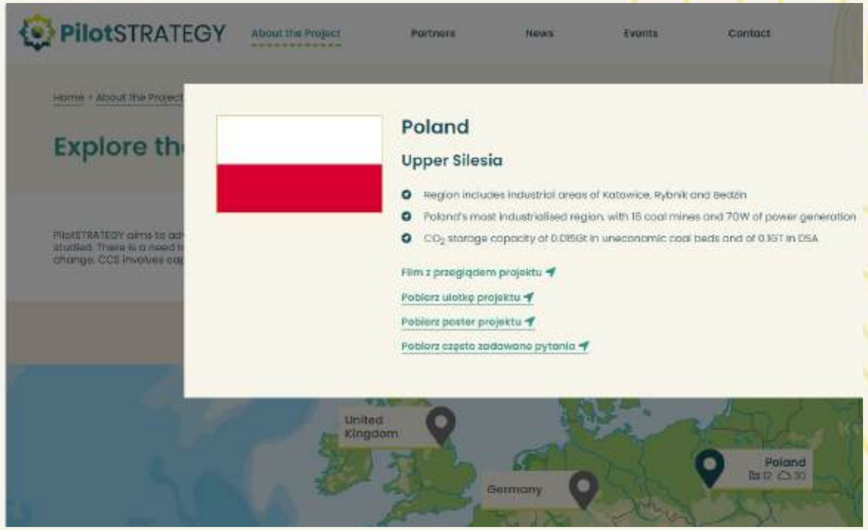
The common goal: Planning of a potential CCS pilot in Upper Silesia - DISCUSSION

WP6: Regional Stakeholder Committee workshops conclusions

1. **It is necessary to conduct a large-scale social campaign** aimed at providing residents with reliable information about CCS issues. The information should be specific and provided by reliable people who enjoy social trust and, due to their competences, may constitute an authority for people. At the moment, in Poland there are no authorities based on which public trust in CCS can be built.
2. Another **detailed survey of the inhabitants of the areas considered for CO2 storage after selecting specific locations**.
3. Regulation of legal issues and involvement of national and local authorities in the development of CCS technology.
4. Finding a source of financing for the project (planning and creation of the pilot; in the case of an industrial installation, it will probably be easier to find investors).
5. A comprehensive approach to the issue and the involvement of competent people at every stage of the project, starting from legislators through professional employees responsible for the technical side (geologists, designers, etc.).

WP7: Dissemination and Exploitation

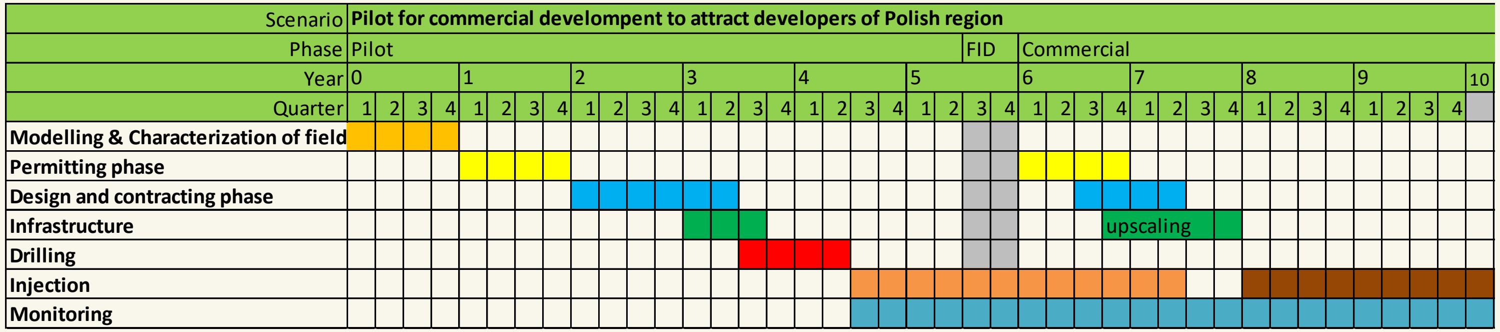
- On December 14, 2023, a consultation meeting was held on proposed solutions for storing carbon dioxide in the rock mass. Organized on the initiative of the **Director of the Office of the Silesian Association of** Municipalities and Districts (ŚZGiP). The meeting attracted great interest. Additionally, at the request of the organizers, the materials were forwarded to the **Geology, Mining and Ecology Committee** of ŚZGiP for further promotion.
- Preparation of a film in Polish informing about the project: PilotSTRATEGY Project Overview - Polish (Film z przeglądem projektu) (youtube.com)
- Evidence-based answers to region-specific frequently asked questions (FAQ): Poland: https://pilotstrategy.eu/sites/default/files/inline-files/PilotSTRATEGY%20FAQs%20-%20Poland.pdf
- 24 October 2024 r. Inernational Webinar 3 - Upper Silesia, Poland: Activities, results, challenges. https://pilotstrategy.eu/events/webinar-3-upper-silesia-poland-activities-results-challenges
- 24 November 2025 r. Inernational Webinar: COREu meets PilotSTRATEGY Geological Perspectives on CO2 Storage in Central Europe: Czech Republic and Poland



Upper Silesia – Łądzice DSA

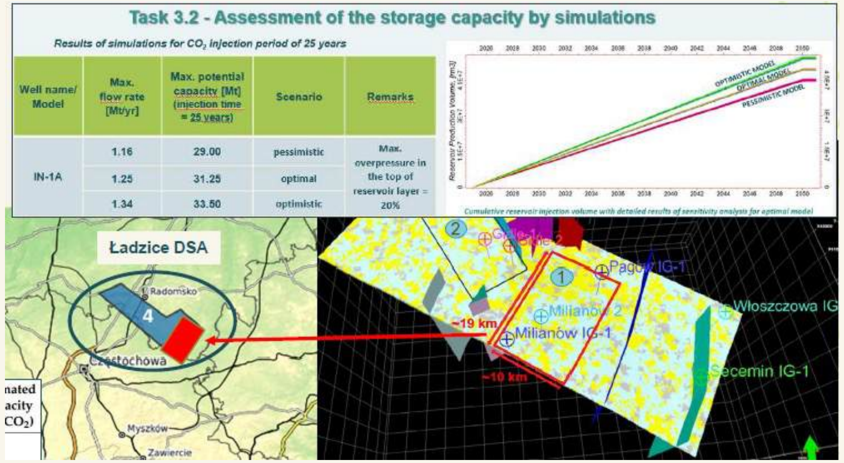
Capacity	**31 Mt**
Total CO_2 stored	**7,6 Mt *(~25%*)***
Pilot:	**3 years – 30 kt/y (road transport)**
Commercial:	**25 years – 300 kt/y (pipeline)**
CAPEX	**255 MEUR**
OPEX	**725 M EUR over 30 years**

**Scale adjusted to single well*



The investment is **profitable** assuming the **highest prices** for CO_2 emission allowances and taking into account the **commercial phase**.

Phase	CAPEX		OPEX	
	mln EUR	EUR/t CO_2	mln EUR	EUR/t CO_2
Pilot phase	21	234	26	292
Total Pilot + Commercial + Monitoring	255	34	725	96



CAPEX

- 3D seismic research
- Modelling, technical documentation, permits and administrative decisions
- Wells - drilling + completion, incl. monitoring devices
- Pipeline construction
- Land, infrastructure on the ground surface

OPEX

- Electricity
- Monitoring
- Salaries
- Local taxes, insurance
- Maintenance and repairs
- Cost of CO_2 capture
- Cost of CO_2 transport (road / pipeline)
- CO_2 injection

Legal conditions for the use of the technology in Poland

National regulations – amendment

- ✓ Work is underway on the so-called location regulation. This is a draft amendment to the regulation on areas where underground carbon dioxide storage complexes are permitted. The draft was published by the end of 2025 for consultation.

- ✓ This will amend a document drafted 11 years ago, which designated only the offshore area in the Baltic Sea (exploited hydrocarbon deposits and their surroundings – an area of 1,390 km²) for storage purposes. The new version will allow the creation of CO_2 storage sites in other locations, primarily onshore.

CCS way forward in Upper Silesia - Poland

- **Project Ładzice CO2**

Ładzice CO2 Pilot: Demonstrating Carbon Capture and Storage in Europe's Coal Heartland

Call: HORIZON-CL5-2026-03
(BATTERIES and ENERGY)
Topic: HORIZON-CL5-2026-03-D3-29
Type of Action: HORIZON-IA
(HORIZON Innovation Actions)
Proposal number: 101338095
Proposal acronym: LADZICE CO2

1 Cquestra B.V. Netherlands Coordinator
2 THE UNIVERSITY OF EDINBURGH, UK, Partner
3 GLOWNY INSTYTUT GORNICTWA - PANSTWOWY INSTYTUT BADAWCZY, Partner
4 FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANG, Germany, Partner

CCS way forward in Upper Silesia - Poland

- **Project Ładzice CO2** has three main objectives as following:

 Obj 1 “Unlock CO 2 storage capacity”: To complete storage site characterization and perform an injection test to increase readiness and confidence of Ladzice DSA. The storage site Ladzice DSA has an estimate CO_2 storage capacity of 100 Mt with Pągów-Milianów selected area contributing with 30Mt of CO2 storage capacity. It is linked to CCS scenarios to decarbonize Upper Silesia emitters and negative emissions through BECCS.

 Obj 2 “Permitting ready”: Reinforce our cooperation with national competent authority to proceed with permitting and get authorizations on time to perform the geological work program and prepare the site for the commercial phase.

 Obj 3 “Increase Societal Readiness on CCS technology”: To involve local stakeholders in the decision making process, integrating their needs and concerns into both financial and non-financial KPIs, in order to secure societal support for operating a commercial-scale CO_2 storage site.

Main Findings, insights, challenges

- The main objective of the Upper Silesia Region in Poland was to prepare our region for the first carbon dioxide sequestration facility. To achieve this, **we had to identify suitable geological structures, confirm the storage potential, and model the static and dynamic sequestration process**. The primary goal was to explore how Carbon Capture and Storage can support a just energy transition in a traditionally industrial region, while contributing to wider European climate goals. The partners collaborated with regional authorities, industry, and experts to assess the local potential of CCS and incorporate it into regional development strategies.

- The key successes in Poland include close cooperation between public institutions and industry, active stakeholder engagement, and a better understanding of CCS as a practical climate solution. **The project provided concrete regional analyses and strengthened trust between the various actors involved in the transition**. Undoubtedly, determining the storage potential of Silesia region and the use of mathematical modelling, which allowed for an increase in storage potential, was an important achievement.

Main Findings, insights, challenges

- The PilotSTRATEGY project provides Upper Silesia with greater knowledge, potential, and strategic direction for CCS development. The work conducted by Polish partners as part of the PilotSTRATEGY project describes and characterizes saline aquifers in Silesia. **Local industries that are difficult to decarbonize, such as the cement and metallurgical industries, will benefit from this work in planning decarbonization strategies**. Another crucial element is knowledge on how to prepare and construct the installation in compliance with legal and environmental requirements. The work conducted by the Polish team supports a harmonized approach to decarbonization, strengthens cooperation between regions, and fosters coordinated progress towards climate neutrality in Europe.

PilotSTRATEGY

Thank you for listening

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PilotSTRATEGY

Acknowledgements

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PilotSTRATEGY

The way forward for CCS in Southern and Eastern Europe

Event hosted by

Paulo Cunha – Member of the European Parliament

European Parliament

Brussels, April 21st, 2026

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

Agenda

The way forward for CCS in Southern and Eastern Europe

- **Welcome**

Paulo Cunha – *Member of European Parliament*

- **PilotSTRATEGY outcomes and impacts**

Isaline Gravaud *(BRGM)*
Paula Canteli *(IGME-CSIC)*
Júlio Carneiro *(University of Évora)*

- **Panel discussion**

Chair: Aymeric Amand, *ZEP*

Panelists: Toby Lockwood, Clean Air Task Force
Elisabeth Dütschke, Fraunhofer ISI
Zsuzsanna Szeles, European Commission/DG ENER
Koen Coppenholle, Cement Europe

PilotSTRATEGY project –
CO_2 Geological Storage Pilots in Strategic Territories

Isaline Gravaud – BRGM / French Geological Survey – Project coordinator
Paula Canteli – CSIC-IGME / Spanish Geological Survey
Júlio Carneiro – University of Evora (Portugal)

European Parliament
Brussels, April 21st, 2026

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

PilotSTRATEGY

General framing

- **Support development** of carbon capture and storage (CCS) in **Southern and Eastern Europe**
- Investigate **deep saline aquifers:** large capacity for storing CO_2.
- **Preparing the ground** for full and active development into operational storage sites.

The five-year PilotSTRATEGY project, which commenced in 2021, has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement nº 101022664.

PilotSTRATEGY

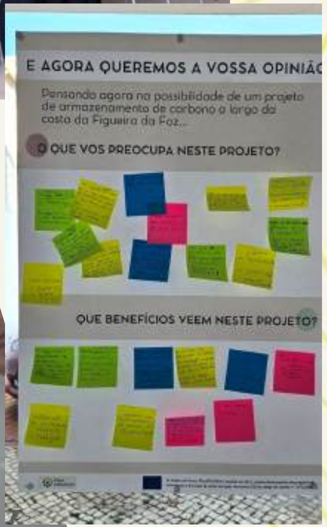
PilotSTRATEGY (H2020 RIA)

- 5 regions studied
- 16 partners (+ 3 FR third parties) from 7 countries
- 5 years from May 2021 to April 2026

Achievements

- **Increasing the maturity and readiness** assessment of aquifer storage resources in five European promising regions.
- **Detailed study** for CO_2 geological storage pilot sites in selected areas of interest.
- Identifying and engaging relevant **end users and societal stakeholders** for the implementation of new CO_2 storage pilots.
- Propose **development plans** for the CO_2 storage pilots.

Societal participation and engagement



Why this matters

- CCS deployment depends on **social acceptance** as well as geology and economics
- Public awareness of CCS is **low**
- **Acceptance is conditional**, not automatically positive or negative

What We Did

Tailored mixed-method engagement with 3,300+ citizens and stakeholders in five regions

Focus: How is CO_2 storage perceived, debated, and possibly accepted?

What policymakers should do

Social and technical feasibility must be developed **in parallel**

- Clarify the role for CCS in climate mitigation
- Provide regulatory certainty
- Enable fair implementation
- Fund engagement

Impact

- **5 pilot sites** with increased geological characterisation and development plans
- Unlocking CO_2 storage in **Southern and Eastern Europe**
- **Local storage** for local emissions
- Increased local, regional and national **public awareness and engagement**
- **Lessons learnt** and methodologies transferable for new projects

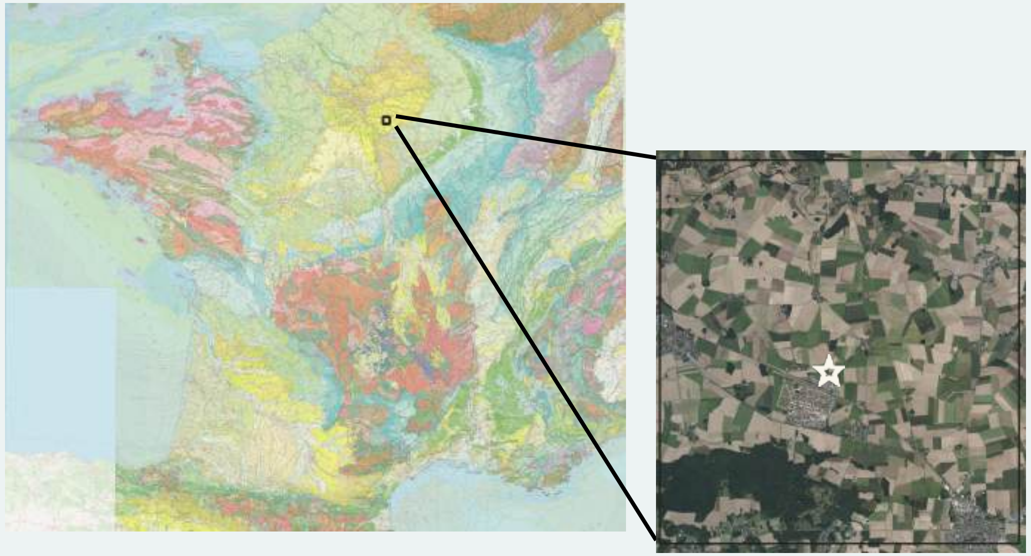
PilotSTRATEGY

Paris Basin Region, France

Isaline Gravaud (BRGM)

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

PilotSTRATEGY in France: Paris Basin



- Location:
  - Paris basin – largest sedimentary basin in France
  - Grandpuits area: agricultural region and industrial history
- Strategy:
  - Pilot project
  - Max 100 kt injected
- Objective:
  - Demonstrate CO_2 storage in France
  - Demonstrate onshore project
  - Explore deep saline aquifers
  - Explore potential for scale up

PilotSTRATEGY in France: Paris Basin

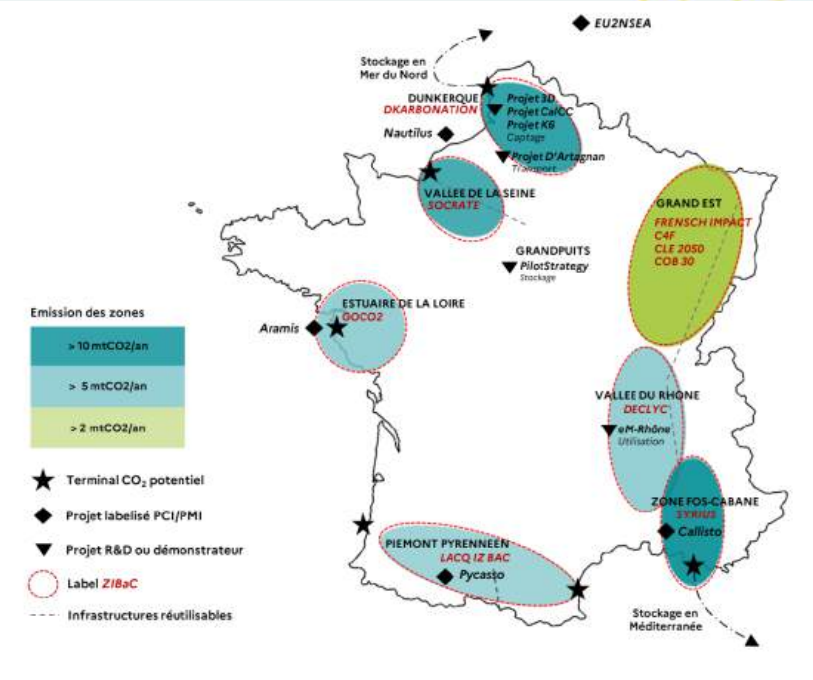
- **A good candidate for safe CO_2 storage pilot**
  - A detailed characterised geological site
  - Risk assessment and recommendations
  - Potential for scale up
- **Pilot development plans**
  - Infrastructures design, monitoring plan, environmental assessment, economic evaluation

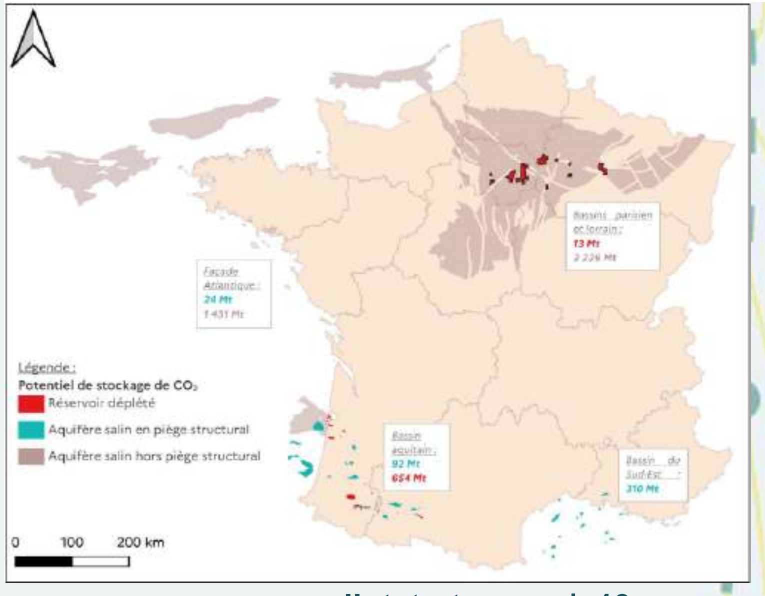
  → All elements for permit request
- **CO_2 sourcing for pilot phase**
  - Industrial context changed with site closure
  - CO_2 purchase and transport by train (similar costs)
- **Social acceptance**
  - Local community engagement activities
  - Increased local awareness for CO_2 storage
  - Disinformation activities by a local association
  - Lack of perceived local benefits since the industrial activity stopped. Importance of the origin of captured CO_2.

→ The Grandpuits site attracted interest from Dutch company C-Questra, which is applying for exploration permit in the area

Developing domestic storage capacities in France

- **French national CCUS strategy**
  - Capture objectives in industry
    - ➢ 4-8 Mt CO_2/an by 2030; 12-20 Mt CO_2/an by 2040; 30-50 Mt CO_2/an by 2050
  - Storage sites
    - Short and medium term: **Export** to North Sea storages
    - Long term: develop **sovereign** capacities
- **CO_2 storage capacities in France**
  - To date, **no storage project** in France
  - EVASTOCO2 study in 2023-2024 (involving several FR PilotSTRATEGY partners) to **evaluate storage potential** in depleted fields and saline aquifers
  - **2 exploratory permit applications** under review (Grandpuits and another in Southern France)
  - French regulation: CO_2 storage is allowed on the territory, provided that EU Directive is respected
- **PilotSTRATEGY impact**
  - **Grandpuits site** identified in the French CCUS strategy
  - **Unlock CO_2 storage** in France, esp. in the Paris Basin
- **Challenges and needs**
  - Long **delays** in permit application reviews
  - No previous experience from the administration: **first of a kind** in France
  - **Few players** in storage deployment, lack of business case for pilot
  - Need for political support and funding for CO2 **storage, not only capture**





Ebro Basin Region, Spain

Paula Canteli (IGME-CSIC)

21st April 2026, Brussels

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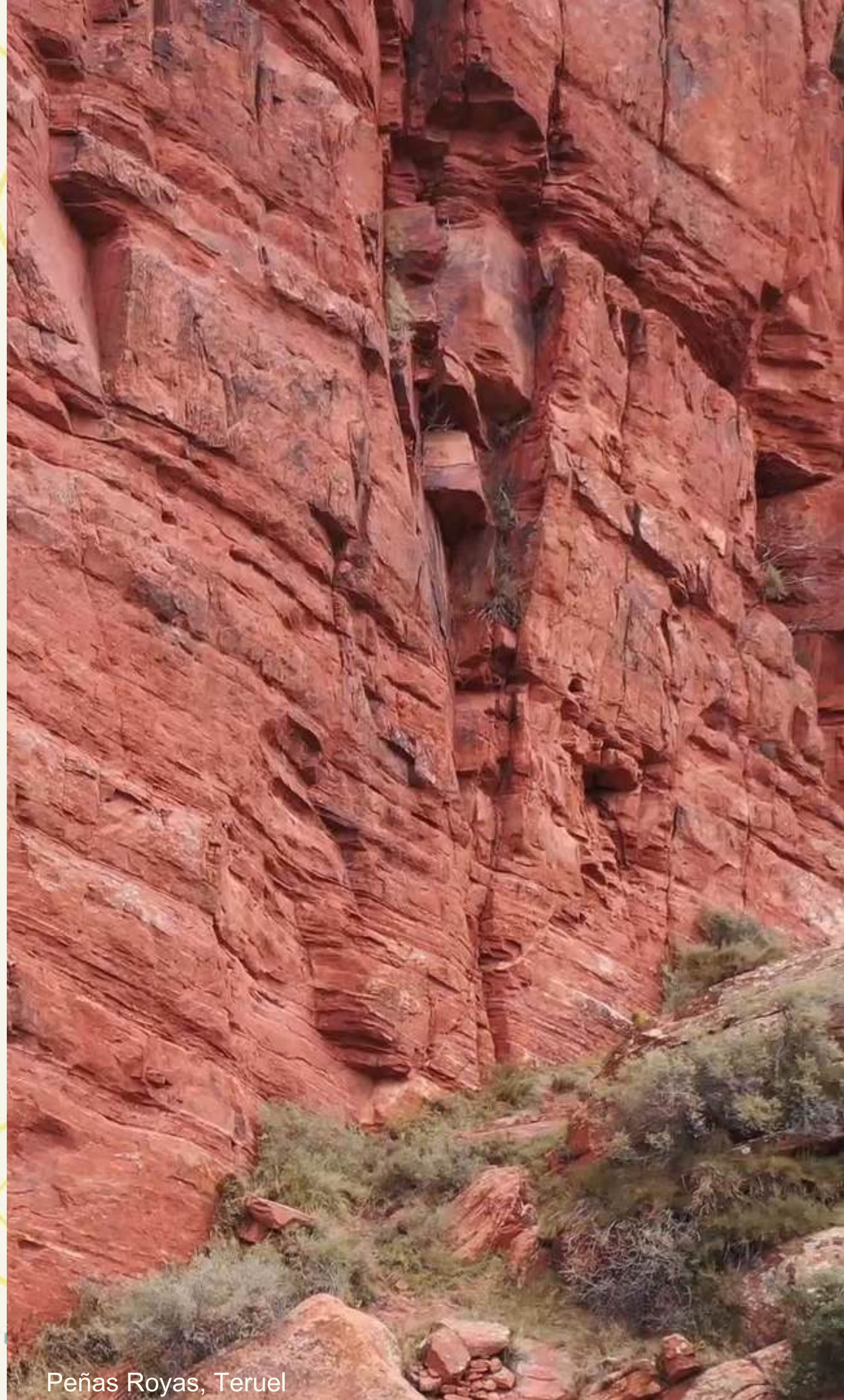



Andorra
Portugal
España
Madrid
Gibraltar
Ebro Basin Region,
NE of Spain
Campo de Belchite, Zaragoza
Onshore CO2 storage

SPAIN
Onshore vs offshore

- Low populated areas
- Lack of opportunities
- Need of fixing population
- Identified onshore potential (national atlas/European atlas)
- Interest of local industry: storage for investing in capture/transport

PilotSTRATEGY

Walk the path and documented for future investors (European directive/national law)

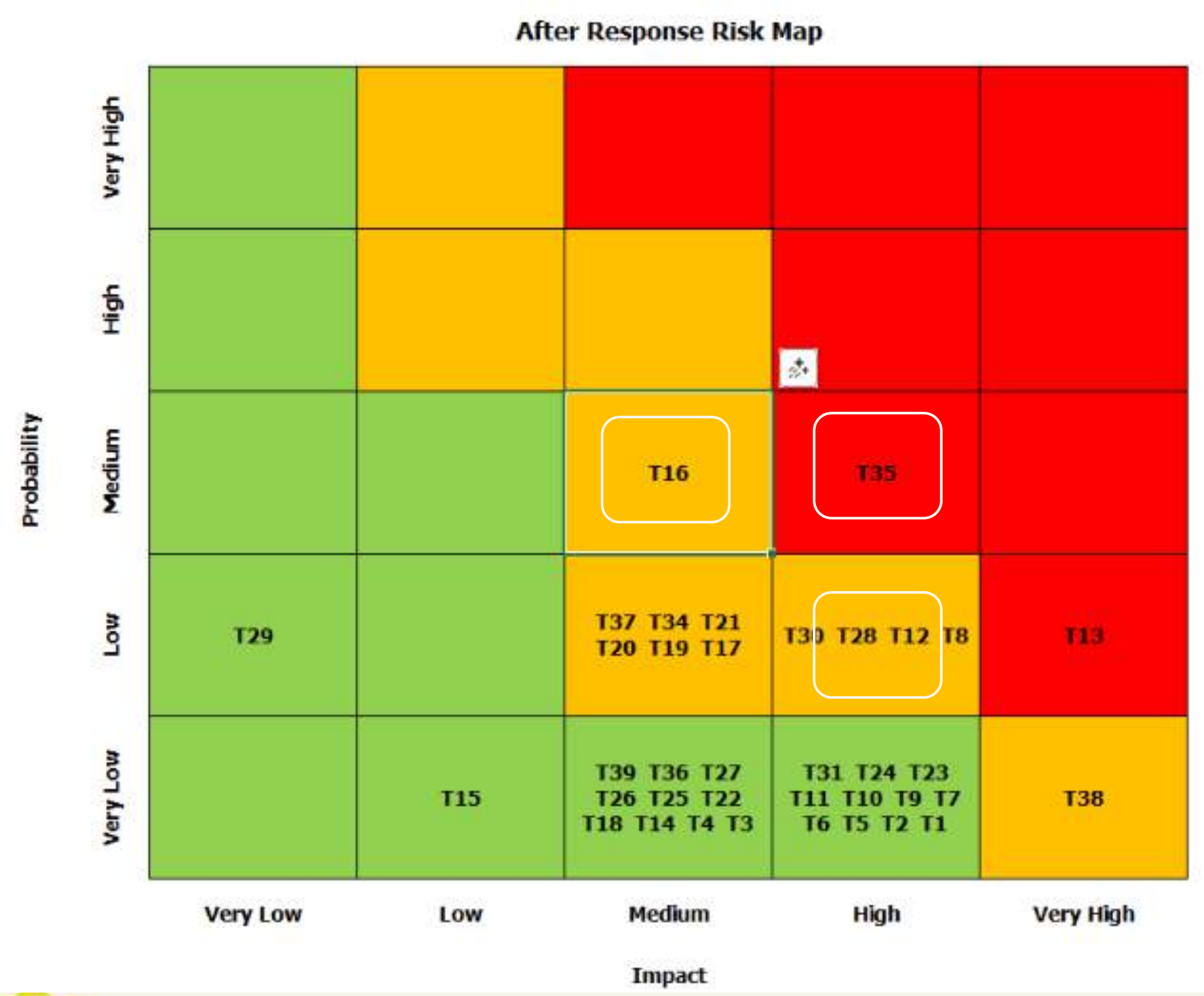
May 2021 → April 2026

- Geological assessment (Static modelling)
- Geological and environmental risks (Dynamic simulation)
- Development concept and design
- Techno-economic evaluation
- Socio-economic assessment
- Regulation and EIA
- Stakeholders and Society license

- 2021-2024: increasing interest on CO_2 storage
- 2024: Investment funds for offshore opportunity
- 2026: Awaiting- on hold interest in national storage sites!

Industry looking for options outside: external storage site penalty national industry!

Multicriteria Risk identification



Risk matrix following Repsol methodology before and after response
T35: Unstable political support and regulatory uncertainty
T13: Unexpected compartmentalization

No technical risks:

- Unstable political support (regional vs national)
- Delays or inability to obtain key permits
- Lack of internal support within the companies due to CCS competing with other business lines
- Lack of financial incentives or changes in CO_2 pricing
- Social polarization

Opportunity

- NZIA accelerated adoption by Spanish authorities

First step: CCS road map

- National Plan of Energy and Clime: only *hard to abate* (25 to 35 Mtpa).

- Road map for CCS:

1. Improve subsurface knowledge
2. Regulatory frame
3. Financial instruments
4. Support to local industry (hubs & infrastructure)

PilotSTRATEGY

Lusitanian Basin, Portugal

CCS – an enabler for Portugal’s Carbon Neutrality and competitiveness

Portuguese team of PilotSTRATEGY

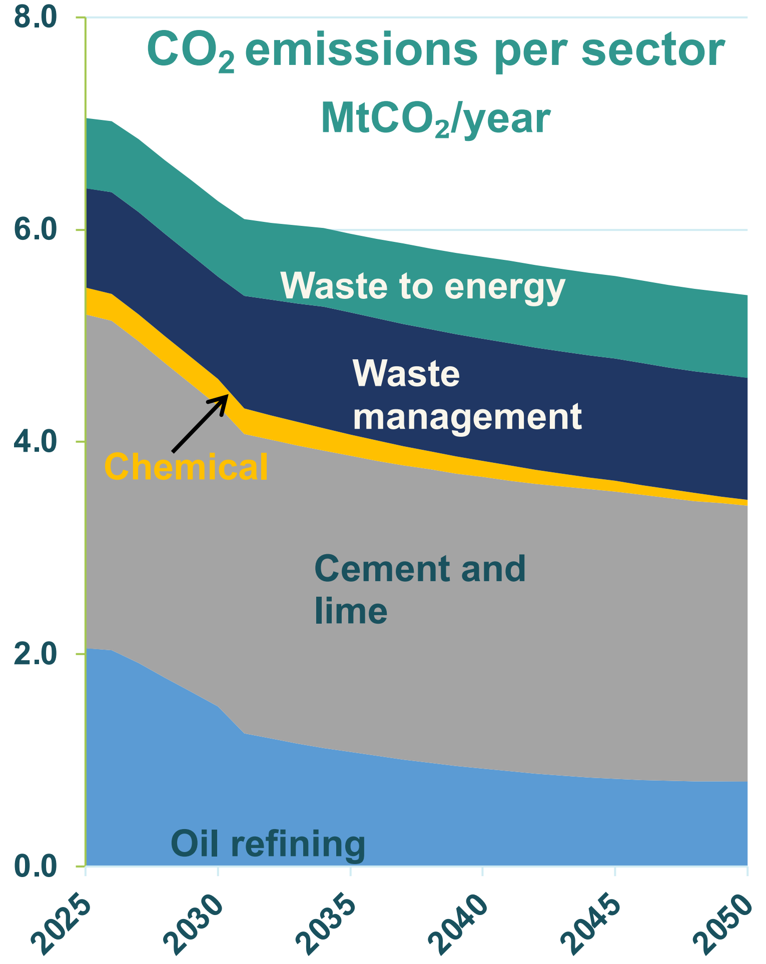
UNIVERSIDADE DE ÉVORA

galp

ICS INSTITUTO DE CIÊNCIAS SOCIAIS

CCS is essential for Portugal

- Portugal aims to reach **Carbon Neutrality by 2045**.
- Hard-to-abate sectors → 5 to 6 Mt/year unavoidable emissions by 2050. **These are process-driven**.
- The phase-out of free ETS allowances will increase carbon-cost exposure for those hard-to-abate sectors.
- Trans-european CO_2 transport networks are important, but not enough – **Southern Europe needs local / regional solutions for CO_2 storage**
- **CCS is structurally required to reach net-zero and to ensure viability of national industry.**



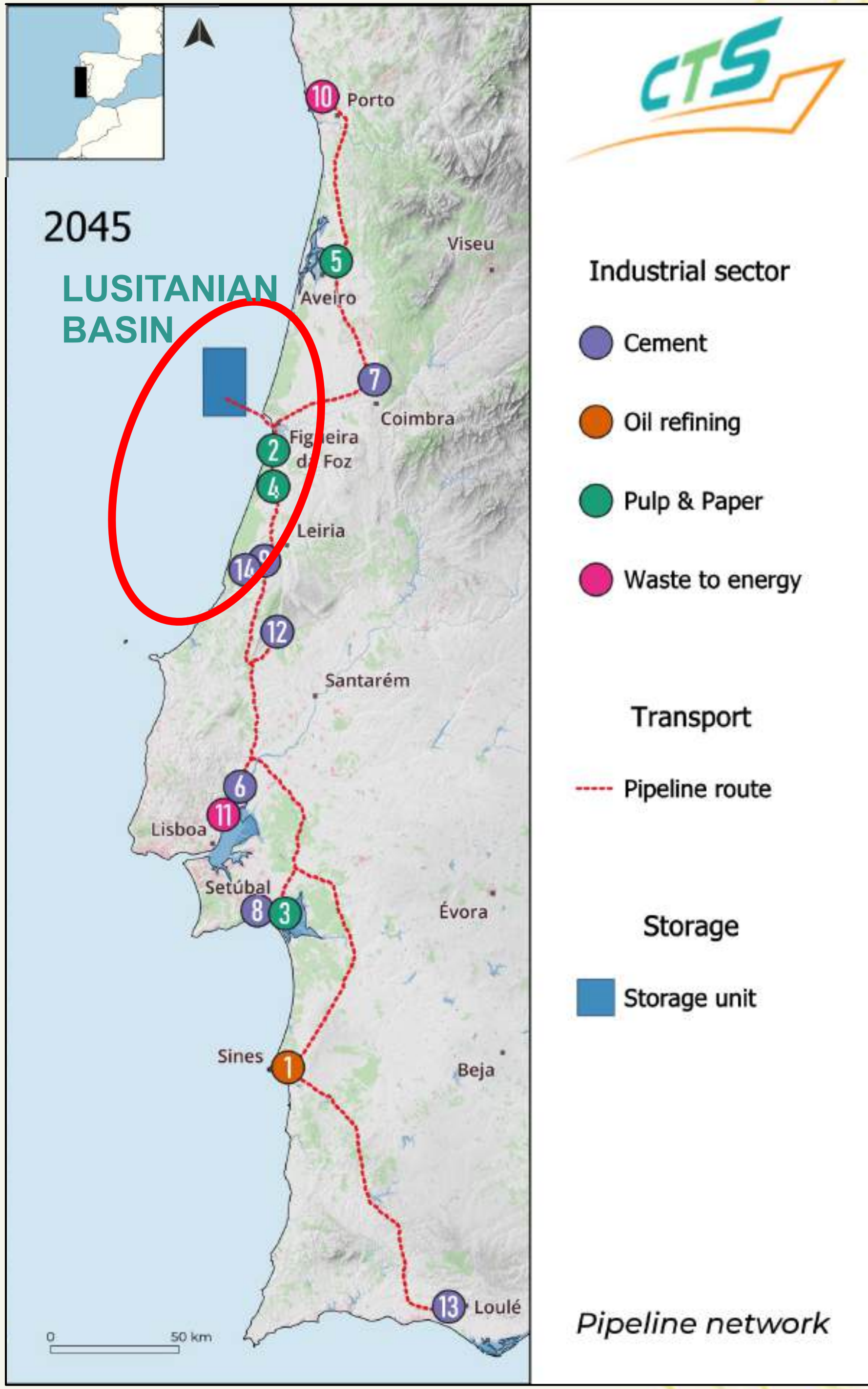
Source: CTS project scenarios

Portugal has a plan for large-scale CCS

- A national-scale CCS pathway has been identified – commercial scale to start in 2035.
- Focus on hard-to-abate sectors.
- High potential for BECCS.

	From 2035 to 2065
Pipeline network	700 km
Storage	287 Mt
CO2 abated	227 Mt
Negative emissions (BECCS)	135 Mt

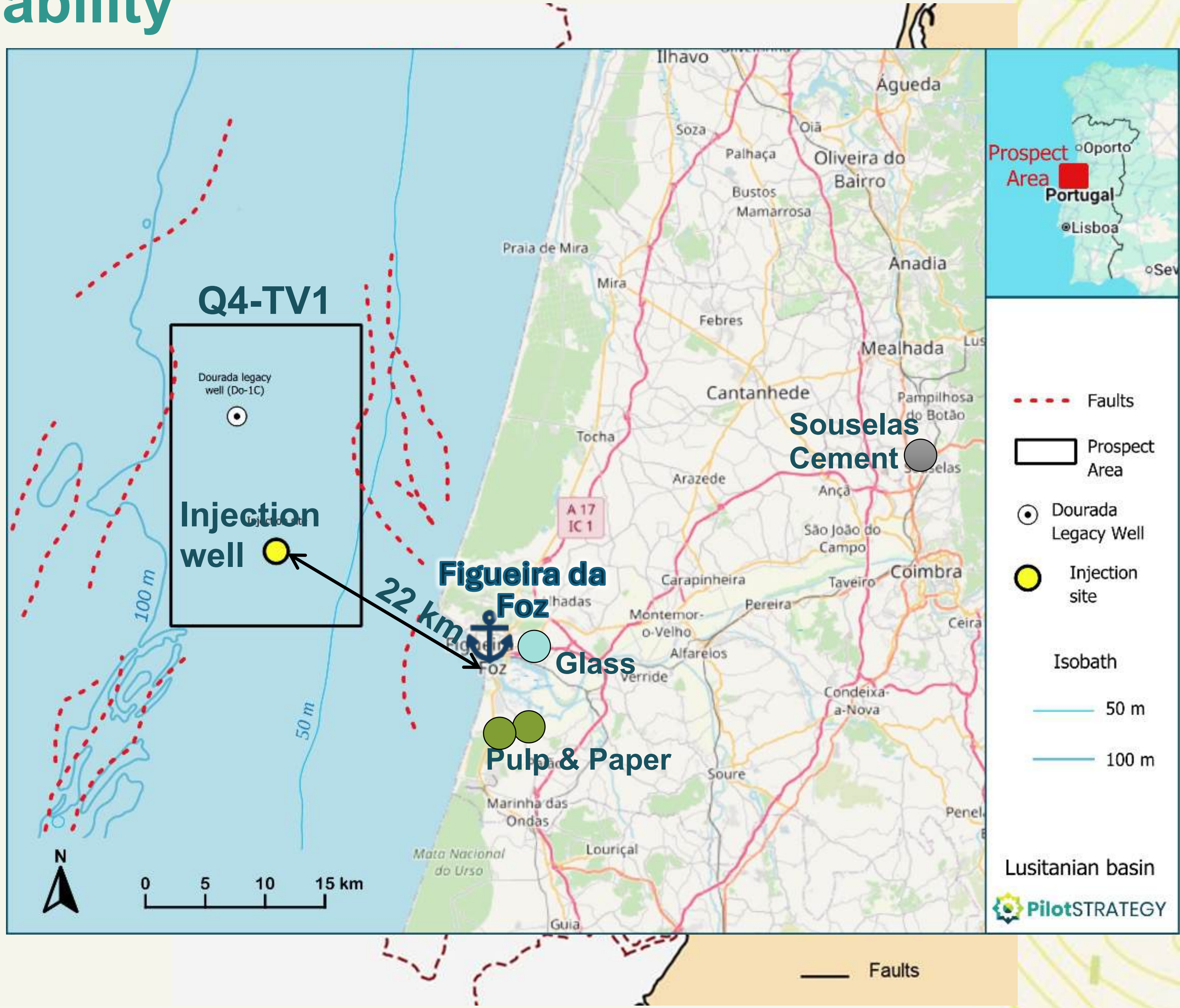
- **Demonstration of Storage capacity** was the weakest element.
- Main goal of PilotSTRATEGY - **design storage site in the Lusitanian Basin**



Offshore storage for scalability

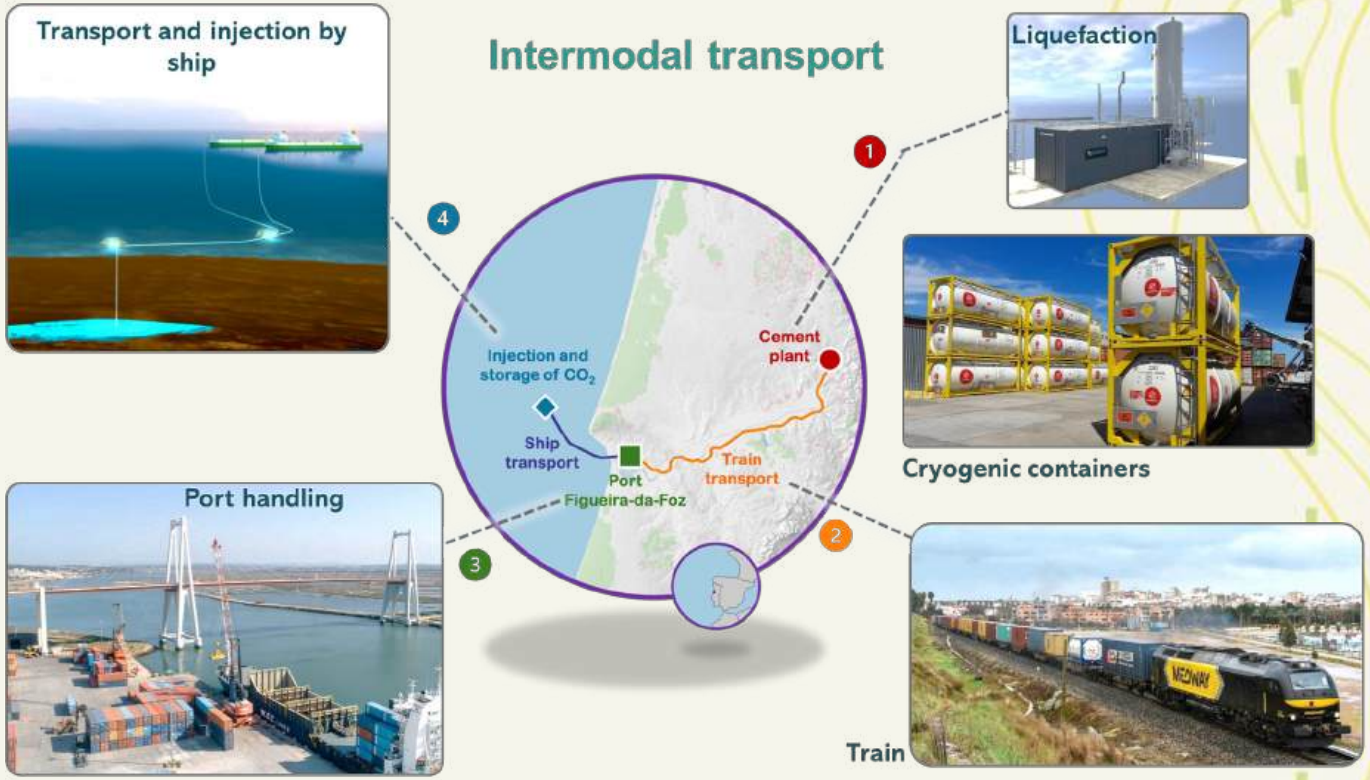
Offshore storage enables the scale Portugal needs for CCS.

- Storage site 22 km offshore from **Figueira da Foz Port.**
- **Excellent reservoir and very low risk area**
- **Storage capacity > 93 Mt** in a single structure.
- Other sites nearby ensure the country storage needs.



Flexible transport enables early CCS deployment

- Start small < 100 kt injection from cement plant.
- **Intermodal transport:** cryogenic containers - rail and ship
- **Direct injection from ship:** address local concerns – no platform
- Transport blueprint for other regions / small scale emitters?
- Portugal can start the pilot **without locking into full-scale infrastructure.**
- **Scale up to pipelines in 2035.**



The timeline starts now!

The timeline to get to large-scale CCS deployment by 2034 requires the pilot phase to start now.

Regulatory issues are a major problem for scale up - time to start solving.

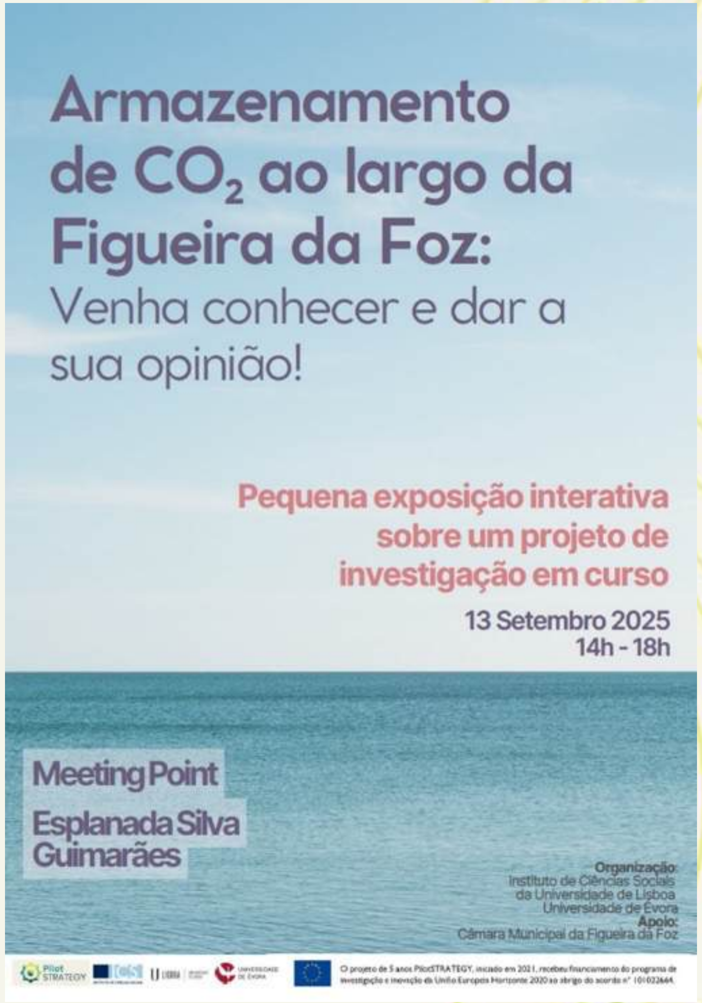
Stakeholders are engaged!

PilotSTRATEGY stakeholder committee - **main achievement**

- **Climate and energy planners** acknowledge the need for CCS
- **Regulators** (APA, DGEG, DGRM) are engaged and aware of the challenge**.**
- Hard-to-abate **Industry** is ready and willing to start.
- Sectors with biogenic CO_2 are looking for a framework for carbon removal - **negative emissions**.
- **Local authorities** (municipality, port authority) are involved and proactive.

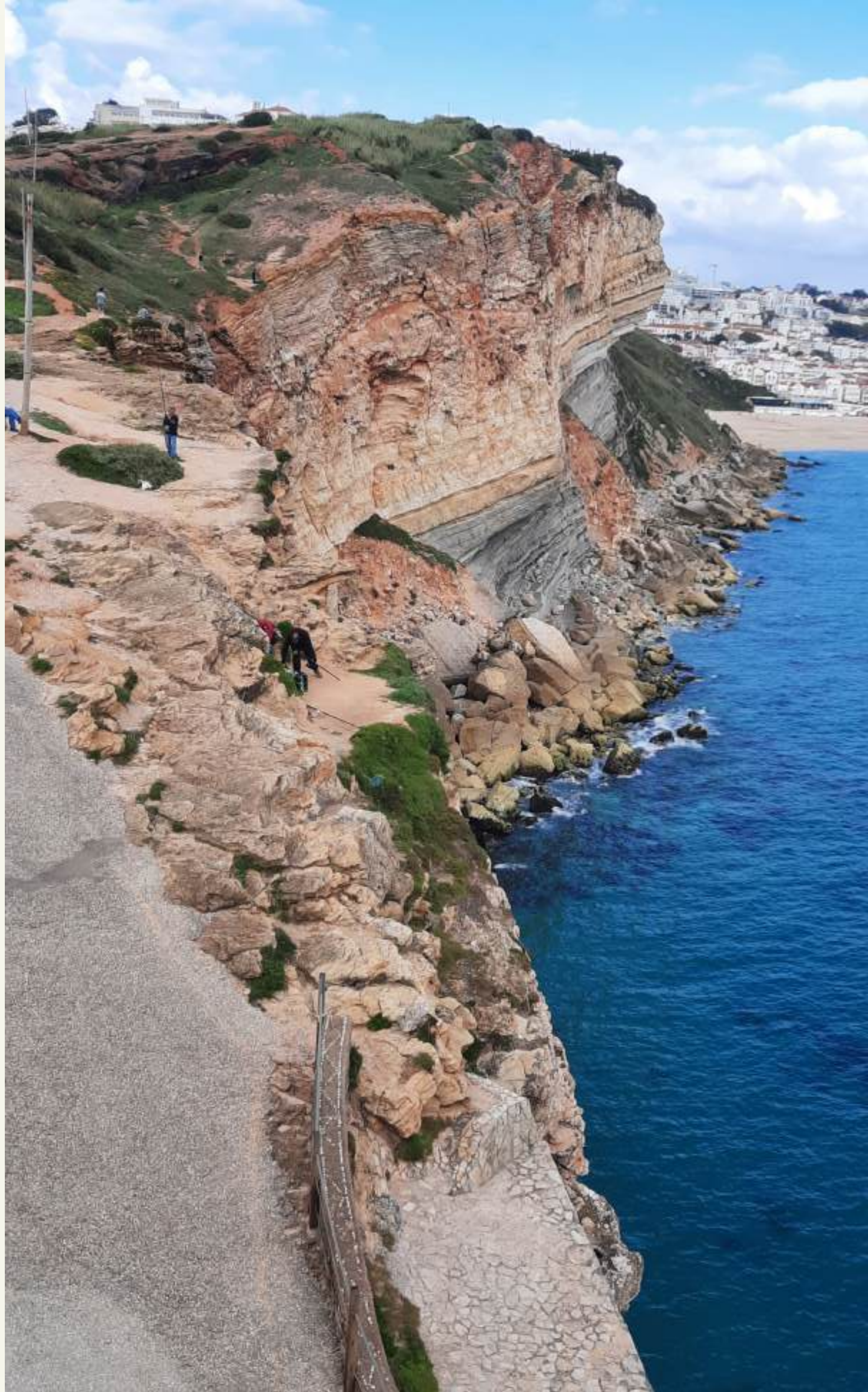
Continued public engagement and transparent monitoring will be essential.

PilotSTRATEGY - **Citizen engagement activities in schools and with general public.**



A European cohesion issue?

- Access to CO_2 storage is becoming a **European cohesion issue.**
- Equal opportunity across Europe – **industrial competitiveness.**
- Southern Europe needs **regional storage options,** not only access to distant hubs.
- Funding instruments should better **recognise first-of-a-kind storage characterisation** in regions without O&G legacy.
- **Regulations to CO_2 transport** and access to it, including non-pipeline transport
- Carbon removal frameworks are needed for BECCS – **key for net zero by 2045 in Portugal**



A clear policy signal is needed now

In Portugal, the main barrier is now **political and regulatory.**

- **Political authorities support** is crucial, and it should be signalled.
- **Stakes are high**: the 2045 target becomes much harder to reach; industrial competitiveness will face increasing pressure.
- **Regulatory hurdles** are identified and can be addressed.
- **Decisions are required** - the Pilot must start in 2027 to go commercial by 2035.

PilotSTRATEGY

Key message

- **Promising storage** sites for CO_2 storage in 5 countries in Southern and Eastern Europe
- Potential to **decarbonize local / national industry**
- Need clear **political support**
- Need **funding** to move forward with storage development

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PilotSTRATEGY

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The way forward for CCS in Southern and Eastern Europe

Panel discussion

Moderator: Aymeric Amand
Zero Emission Plateform

Zsuzsanna Szeles
European Commission
DG ENER

Toby Lockwood
Clean Air Task Force

Elisabeth Dütschke
Fraunhofer ISI

Koen Coppenholle
Cement Europe

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