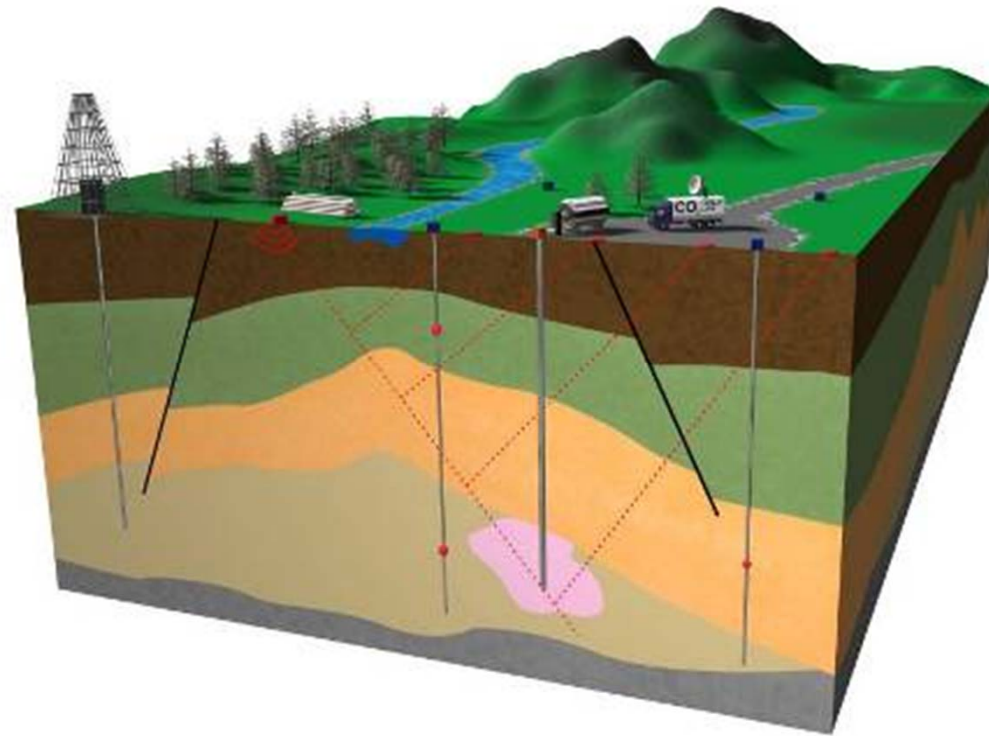


# Ongoing research on shallow migration of CO<sub>2</sub> at CO<sub>2</sub> Field Lab in Sveldsvik (Norway)

Presented by Marie-Laure Olivier  
SINTEF Petroleum Research, Trondheim, Norway

6<sup>th</sup> CO<sub>2</sub>GeoNet Open Forum, *May 9-11 2011*  
*Venice, San Servolo Island*

***” It is of no use to monitor a reservoir without knowing the sensitivity of the monitoring equipment.”***



# Background

- Regulatory framework
  - EU legislation
  - Monitoring, Reporting and Accounting protocols
- The issue of leakage must be well addressed
  - Safety: Minimize the Health, Safety & Environmental risk
  - Mitigation and early remediation
  - Public acceptance: credibility of geological storage challenged
  - Accounting: emission credits
- Validated monitoring system for leakage
- Technology assessment

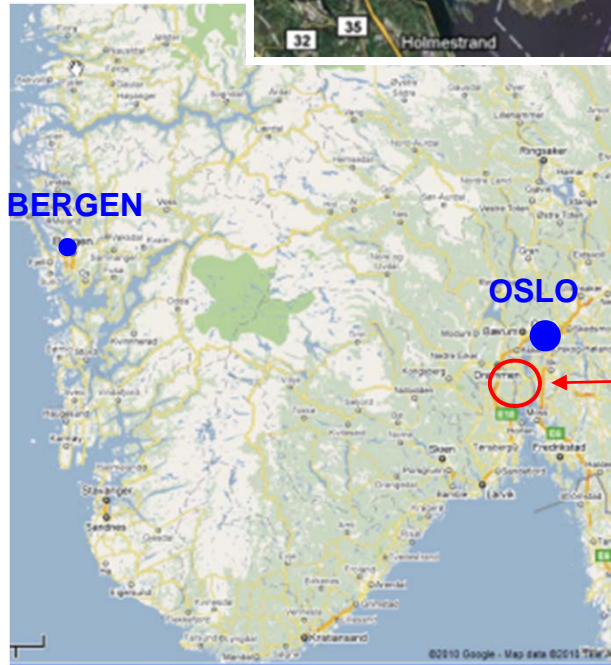
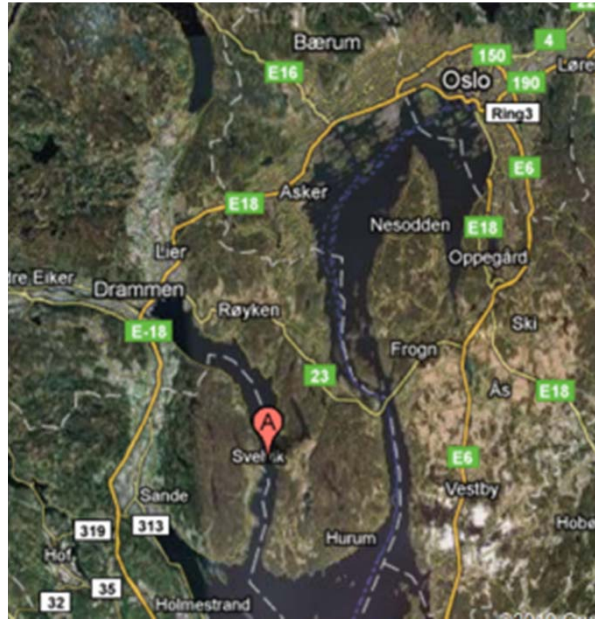
**Crucially  
needed!!!**

# Feasibility study

- Feasibility study was conducted Aug '06 - Jan '07 by 9 Norwegian partners using 0.29 mill. € from Gassnova.
- Two field laboratory sites have been identified in Norway:
  - Svelvik
  - Brumunddal
- For each site a monitoring and modelling program has been designed.

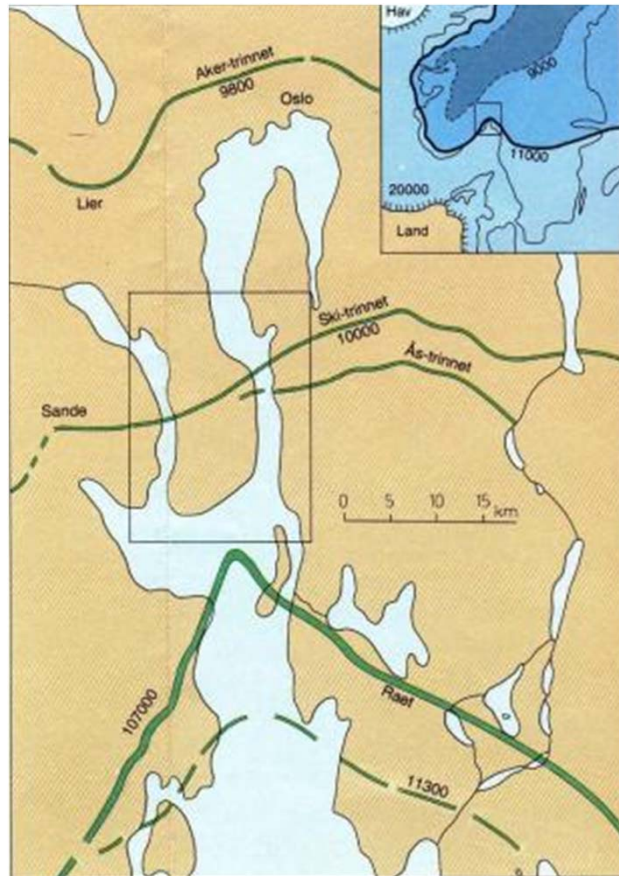
# Location

Svelvikryggen;  
Midway Drammensfjord;  
50 km SW of Oslo

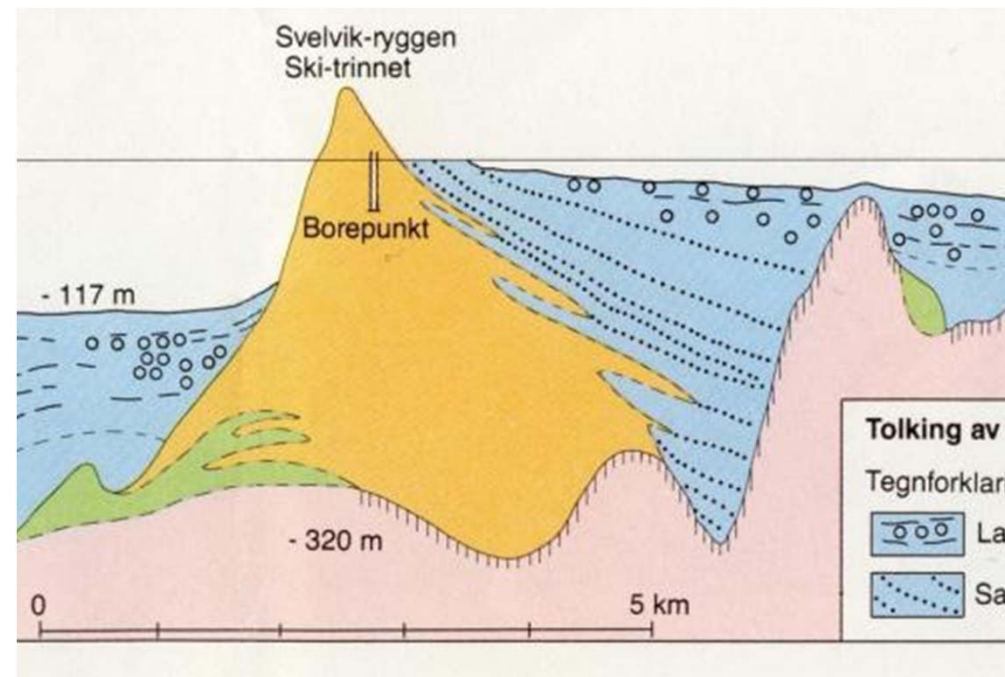




# Svelvik



Terminal glaciofluvio-glaciomarin deposit formed during the Ski stage of Holocene ice recession in Southern Norway



Formation type	Cementation	Dip	Vertical thickness	Permeability / Porosity
Quaternary sand	Uncemented/ Loose	10-15°	~300 m	High

# CO<sub>2</sub>FieldLab in one slide

Small amounts of CO<sub>2</sub> injected in permeable rocks in a well-controlled and well-characterised geological environment. Shallow and very shallow subsurface in a Norwegian field



The underground CO<sub>2</sub> distribution will be monitored with an exhaustive set of techniques deployed by project partners.

# Objectives

## CONTROLLED LEAKAGE EXPERIMENT

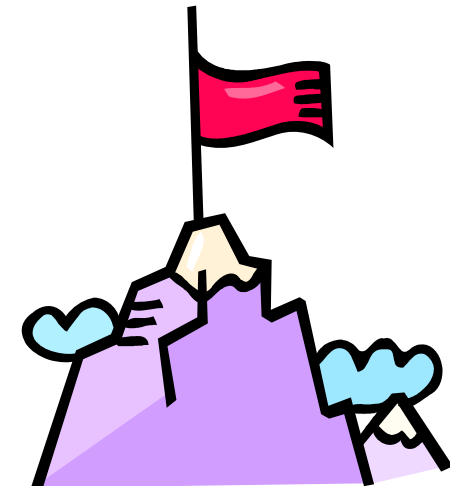
- **CO<sub>2</sub> injection in permeable reservoir**
  - **Shallow** (10-30 m)
  - **Deep** (200 – 300 m, ca. 200 tons in 2-4 weeks)
- Determine **sensitivity** of monitoring systems to **migration & surface leakage**
- Upscale results to **assess monitoring systems and requirements** ensuring safe CO<sub>2</sub> storage
- Test and calibrate **migration models** in well controlled conditions
- **Inform the public** about the safety of CO<sub>2</sub> storage by showing the performance of monitoring systems
- Develop monitoring **protocol / certification** scheme



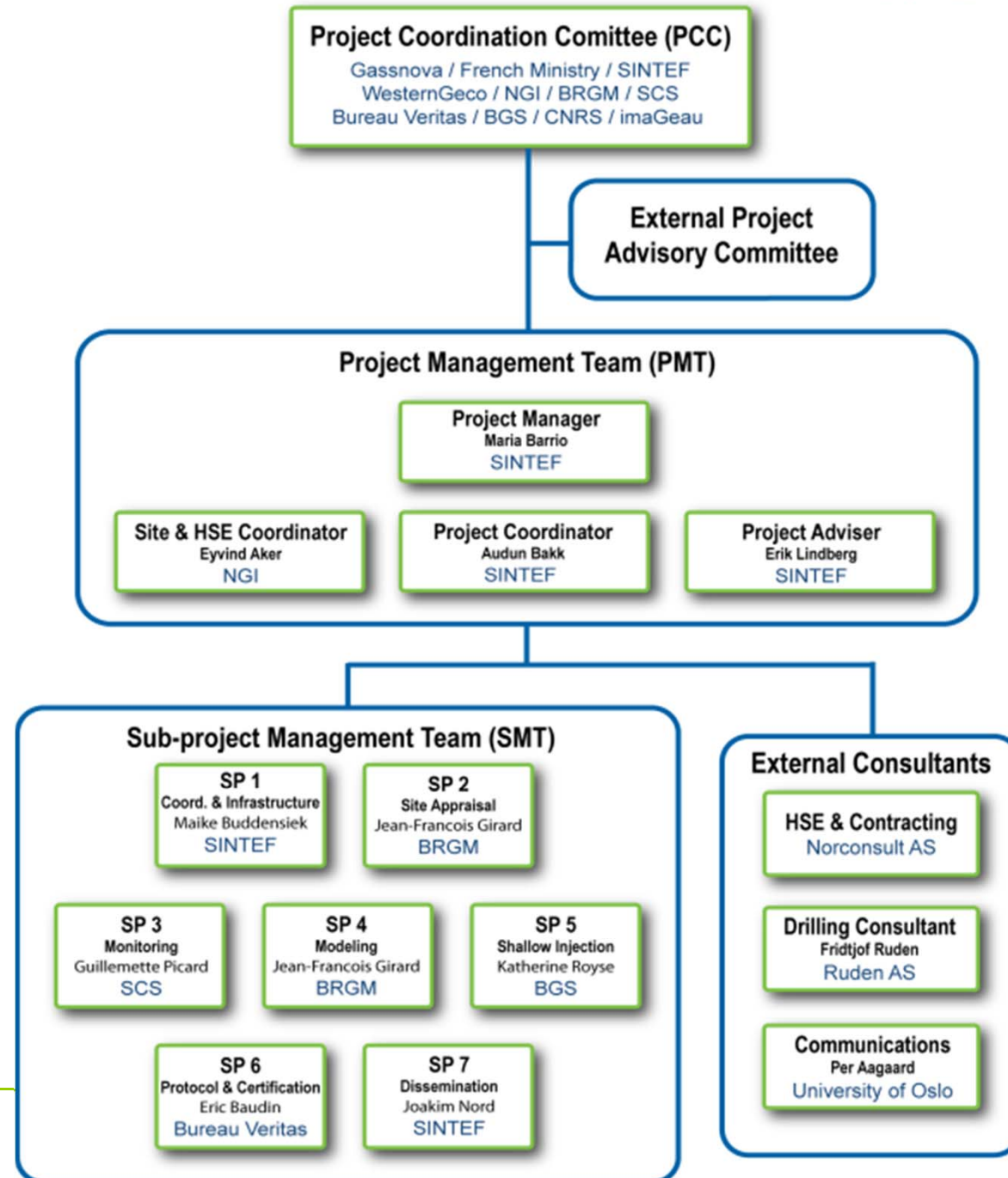


# What makes this project unique?

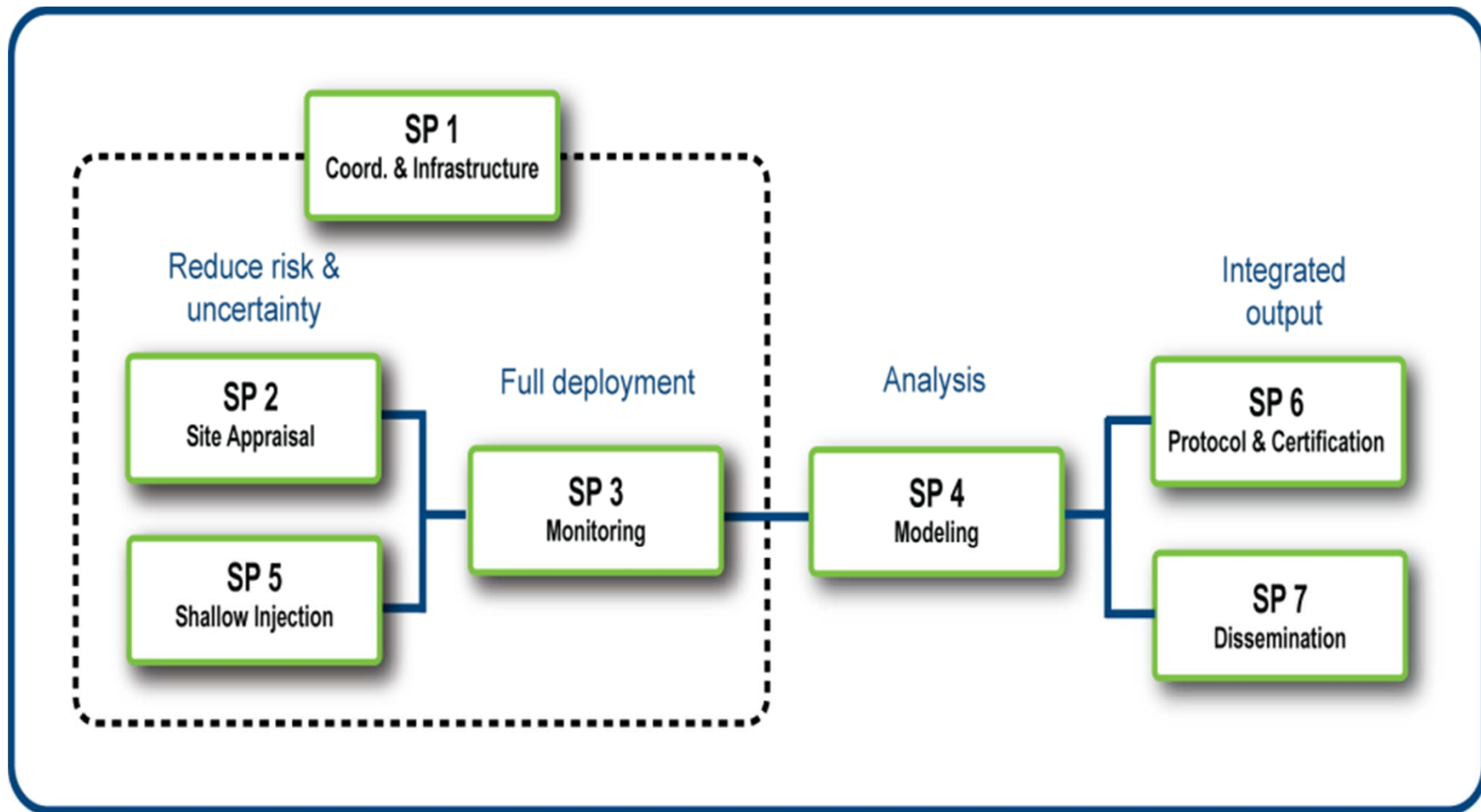
- Detection limits
- Combination of monitoring tools and technologies
- Existing and novel technologies
- Repeatability and permanent networks
- Better option than natural analogues
- Other relevant projects:
  - CO2CRC Otway
  - Montana



# Project organisation



# Project structure



# SP1: Coordination and Infrastructure (SINTEF)

- Technical Site Coordination
- Contracting
- Environment & Permits
- Wells Drilling
- Cores
- Abandonment

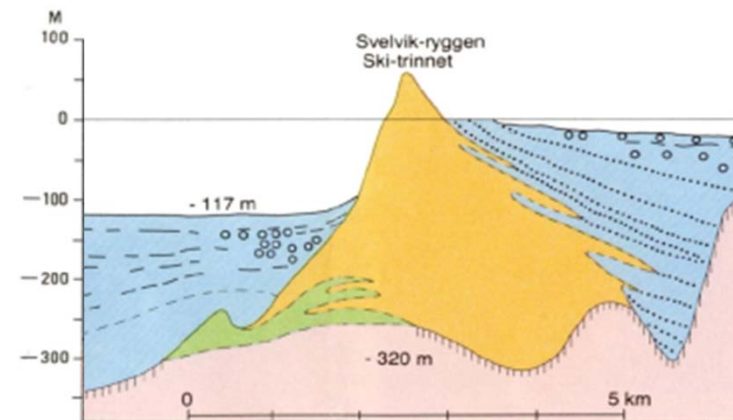


CO2 tank used in a CO2 injection project



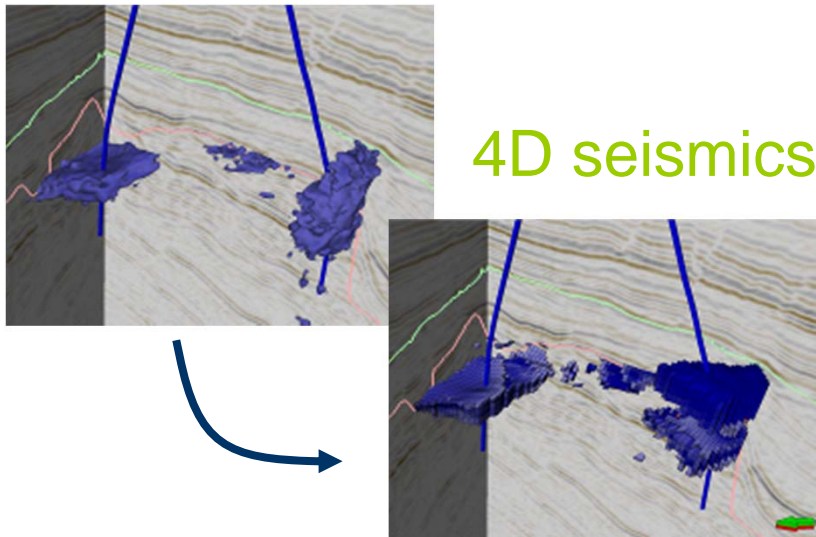
## SP2: Site appraisal (BRGM)

- Site investigation to **reduce uncertainties** concerning
  - **Geology**
  - Suitability for **CO<sub>2</sub> injection**
  - Suitability for **monitoring**
  - **Other risks**
- **Go / No-go** decision
  - alternative site



## SP3: Monitoring (SCS)

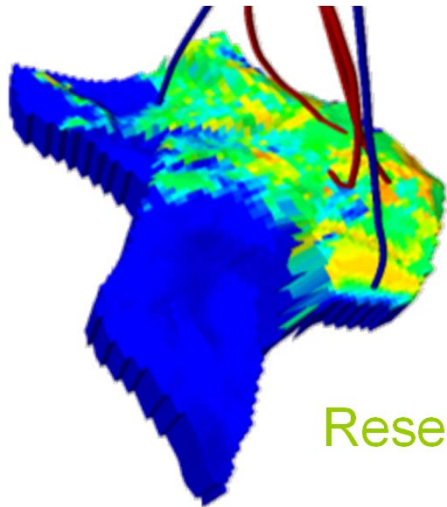
- Determine **sensitivity & performance** of the best available monitoring methods to **detect CO<sub>2</sub>**
  - Surface
  - Sub-surface



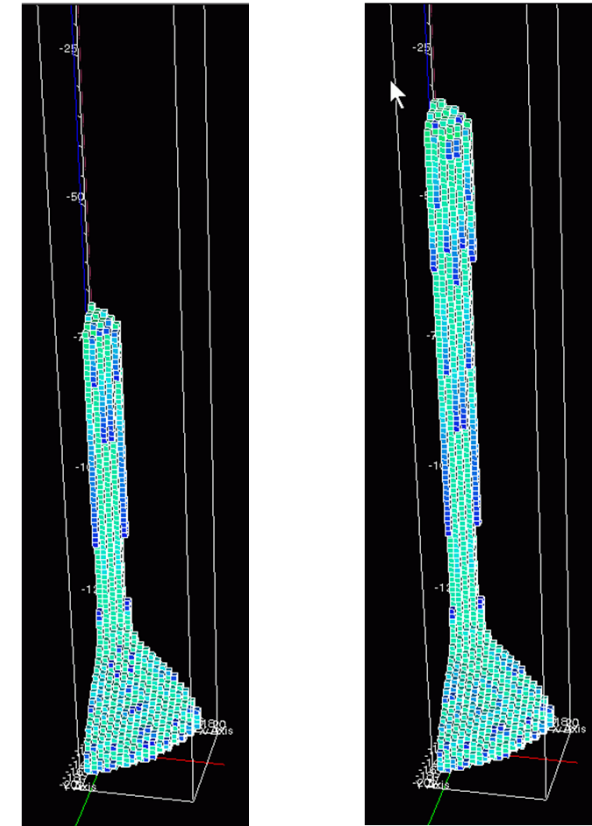
- Baselines measurements for all methods
- Monitoring measurements

## SP4: Integrated modelling (BRGM)

- CO<sub>2</sub> flow & chemistry modelling
- **Upscale results** to assess monitoring systems and requirements that will ensure **safe CO<sub>2</sub> storage**
- Test and calibrate **migration models** in well controlled conditions



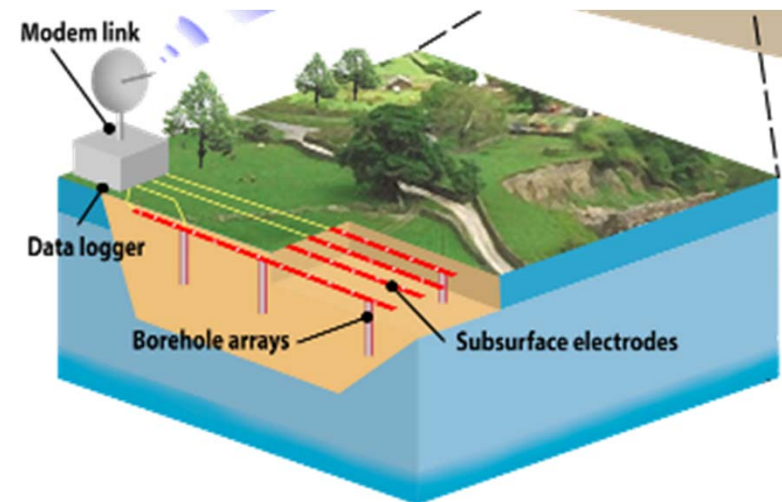
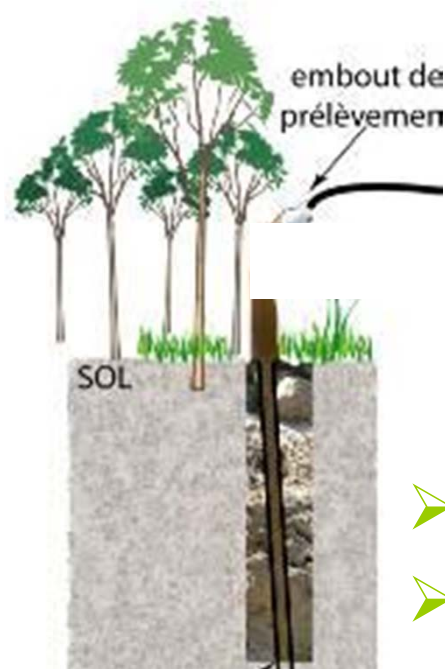
Reservoir fluid flow model



- Processed & analysed data
- Integrated site model

## SP5: Shallow experiment (BGS)

- **Decrease** technology deployment **risk**
- **Assured** surface leakage
- Testing of **tool sensitivity and deployment strategies** prior to deeper injection experiment



- Baselines measurements for all methods
- Monitoring measurements



## SP6: Monitoring Protocol & Certification (Bureau Veritas)

### ➤ What?

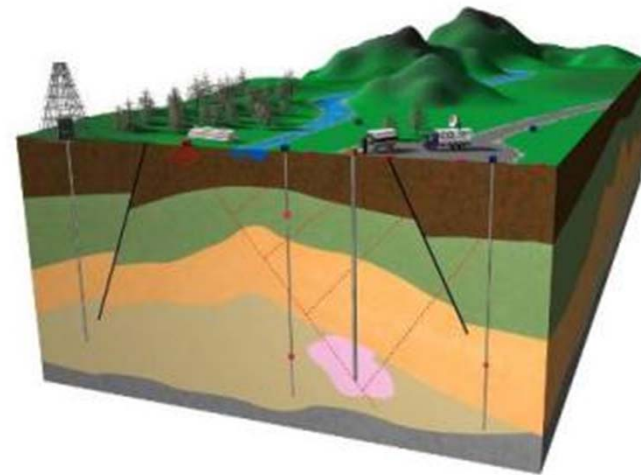
- **Monitoring protocol** is a standardized method of
  - preparing equipment
  - performing measurements
  - interpreting the results
- **Certification**
  - document verifying that Monitoring Protocol has been applied correctly

### ➤ Why?

- **quality assurance**
- **detect & quantify CO<sub>2</sub> leakage** – or lack thereof

# SP7: Dissemination (SINTEF)

- SP7 main objectives are to:
  - Coordinate **internal** and **external** communication
  - Set standards for future storage projects through **communication guidelines**



# SP7: Dissemination (SINTEF)

## ➤ Exposure in media

- Newspaper articles
- Popularised articles
- Norwegian national TV



## ➤ Local community

- Public hearings



- Information about coming/ongoing events

## ➤ Miscellaneous

- Press book
- Scientific publications
- Press releases

# Partners

## France



## Norway



## Great Britain



### Acknowledgments for financial support:

- CLIMIT via Gassnova SF (NO)
- DGCIS, Direction générale de la compétitivité, de l'industrie et des services (FR)



# Project outline

Phase 1: Appraisal phase / site characterization

Go / No-go decision depending on site feasibility (January 2011)

Phase 2: Injection and monitoring phase

- a) Shallow injection
- b) Deep injection

Phase 3: Project closure



# Milestones achieved – phase 1

- Legal groundwork
- Geoelectric / GPR surveys (Nov 09)
- Geological reconnaissance (Feb 10)
- Seismic survey (Mars 10)
- Drilling & logging operations (June 10)
- Hydrodynamic testing (Aug 10)
- Risk & feasibility analysis (extensive modeling) (Nov 10)



# Site characterisation

Geophysical surface measurements	Well measurements	Soil / surface / atmospheric m.
<ul style="list-style-type: none"><li>• 2D geoelectric</li><li>• 2D GPR (Ground-Penetrating Radar)</li><li>• 2D seismics</li></ul>	<ul style="list-style-type: none"><li>• Bore hole logging (300 m)</li><li>• Core sample analysis</li><li>• Injection test</li></ul>	<ul style="list-style-type: none"><li>• Hydrodynamic testing (6 m)</li><li>• Chemical &amp; biological baseline (water, soil, gas)</li></ul>

**Scenario modeling**

# Drilling – June 10



# Timeline – phase 2 + 3

## ➤ Milestones – phase 2

- **July 2011: shallow injection completed**
- **Spring 2012: deep injection initiated**
- **Spring 2013: coupled modelling reported, protocol**
- **September 2013: final report**

## ➤ Milestones - phase 3 (parallel to Phase 2)

- **December 2011: 1st abandonment plan**
- **September 2013: Site abandoned; project closure**



# Monitoring of CO<sub>2</sub>

Geophysical surface measurements	Monitoring well measurements	Soil / surface / atmospheric m.
<ul style="list-style-type: none"> <li>• 4D ERT (Electrical Resistance Tomography), SPT (Seismic Parallel Tester)</li> <li>• EM, NMR</li> <li>• Passive seismics</li> <li>• Active seismics</li> <li>• Time-lapse ERT</li> </ul>	<ul style="list-style-type: none"> <li>• CO<sub>2</sub>, isotopes, induction logging, pressure, temp.</li> <li>• Permanent electrode array, logging</li> <li>• Water sampling</li> <li>• Analysis of bacteria activity</li> </ul>	<ul style="list-style-type: none"> <li>• Soil gas</li> <li>• Surface gas: Laser gas analyser, accumulation chambers, atmospheric tower</li> <li>• Shallow wells: water sampling</li> <li>• Analysis of bacteria activity</li> </ul>

**Modeling:** History matching

# Status

- Project approved by
  - EUROGIA+ board (June 2009)
  - French Ministry (July 2009)
  - Gassnova (CLIMIT Program) (September 2009)
  - CSLF recognition (October 2010)
- Phase 1 concluded (Sep. '09 – Jan.'11)
  - Site characterisation: Geological surveys successfully performed
  - June '10: Drilling and logging 300 m deep exploration well
  - Update models based on logged data
- Phase 2 (start May '11)
  - CO<sub>2</sub> injection and monitoring (2011-2013)
  - Funding secured for 2011. Industrial funding missing for 2012 ++
  - 2011: Very shallow injection and further shallow well appraisal

# Project participation

- Industrial project partner
  - Party in the Project Consortium Agreement
  - Possibility for technology contribution
  - Contribution in cash (and in-kind): 1MEuro + 250 kEuro\*
  - 1 vote in the Project Coordination Committee (PCC)
  
- Member of the Industrial Contact Group (ICG)
  - Arm-length group supporting the project
  - Allowed as observers in the Project Coordination Committee
  - Access to a defined quantity of project results
  - Contribution in cash (not in-kind): 400 kEuro\*

\* Contributions for the total 4 year project, 250 kEuro is late arrival fee

# Contact information

- Maria Barrio, Project manager,  
[maria.barrio@sintef.no](mailto:maria.barrio@sintef.no), +47 735 94 275
- Website: [www.sintef.no/CO2FieldLab](http://www.sintef.no/CO2FieldLab)

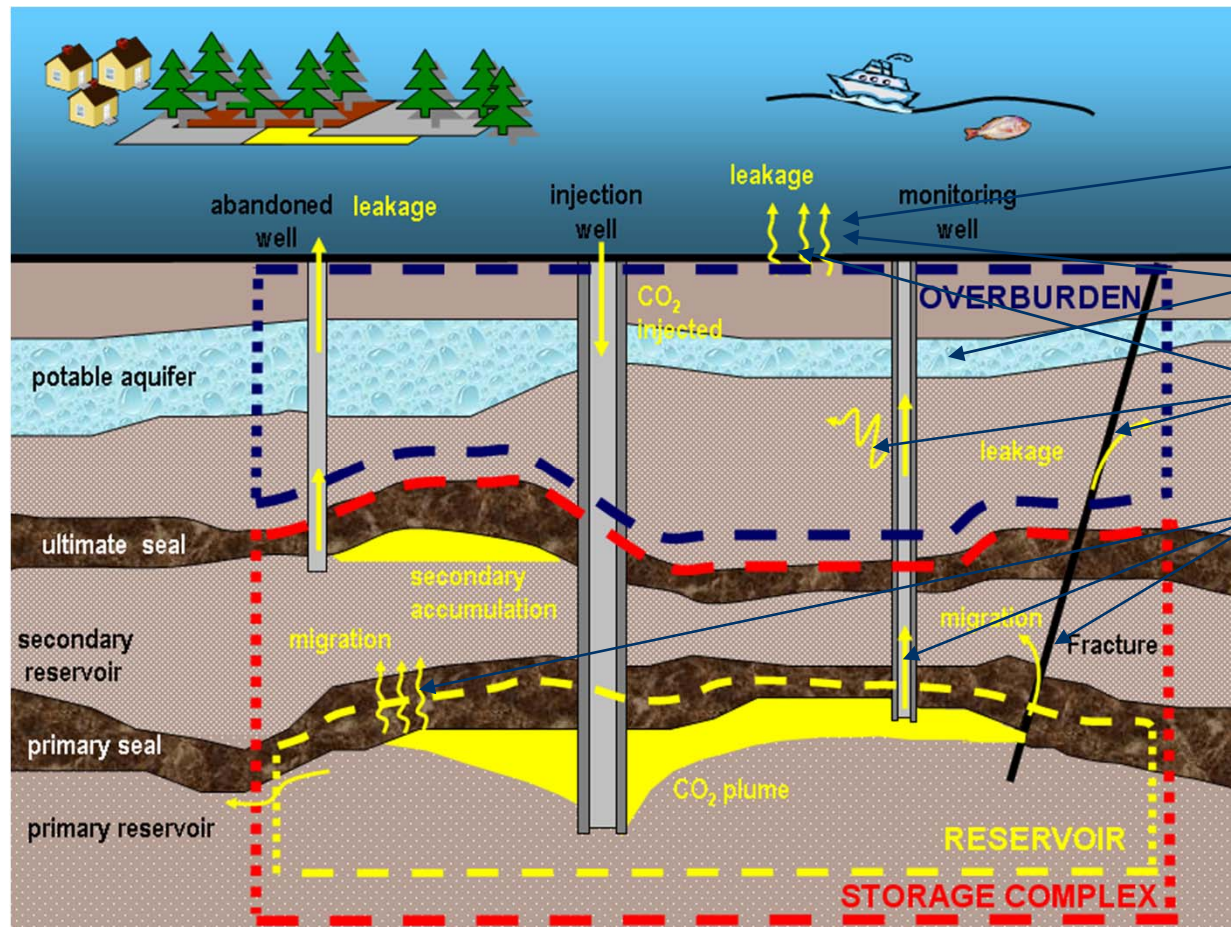






# Assurance Monitoring

Four monitoring activities targeted at controlling containment



4-Leakage quantification

3-Impact detection and evaluation

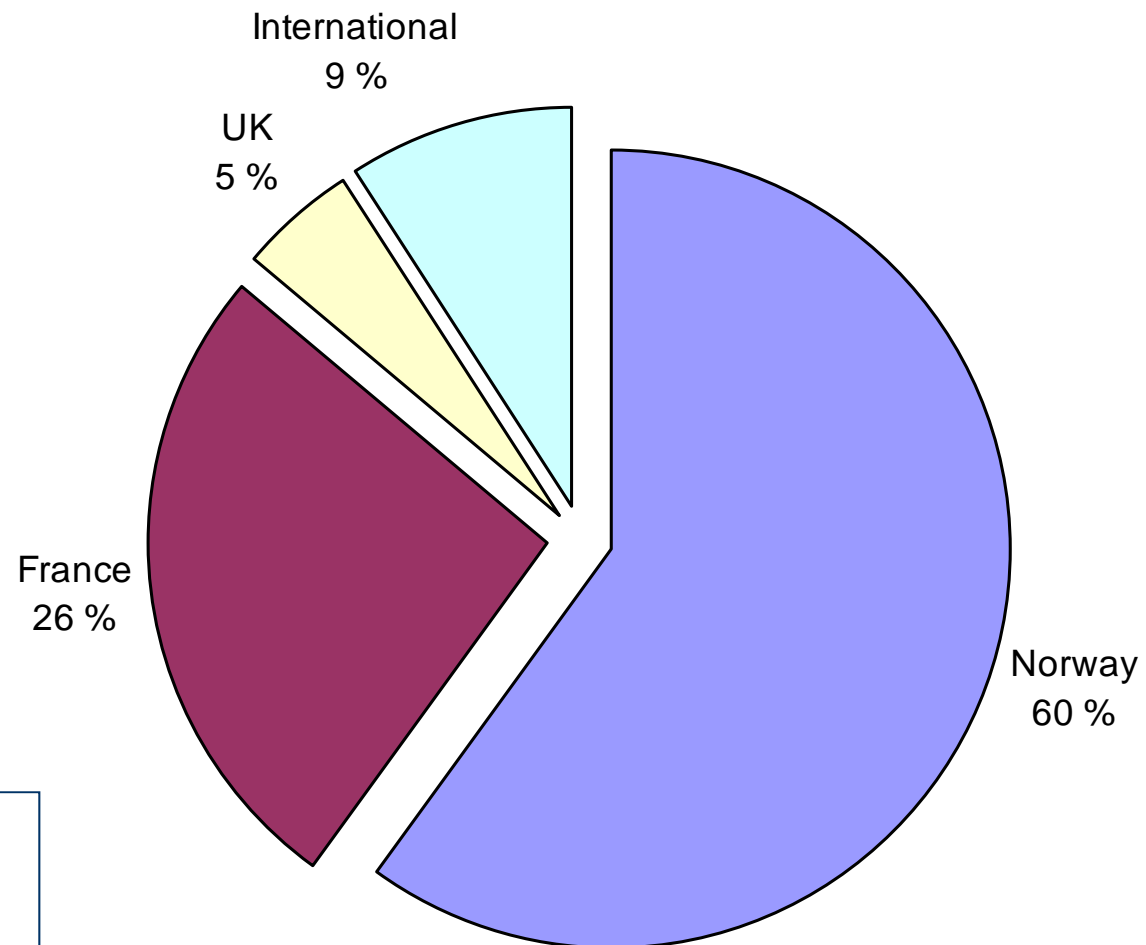
2-Leakage detection

1- Control of barriers' integrity

# Monitoring of CO<sub>2</sub> impact

Geophysical surface measurement	Well measurements	Soil / surface / atmospheric m.
	<b>MW1: WestBay</b> <ul style="list-style-type: none"><li>• Water sampling</li><li>• Analysis of bacteria activity</li></ul>	<ul style="list-style-type: none"><li>• Water sampling</li><li>• Analysis of bacteria activity</li></ul>

# Funding



Industrial funding needed for project continuation