Fifth Annual Conference on Carbon Capture & Sequestration

Steps Toward Deployment

Sequestration in saline aquifers

The French project PICOREF of CO2 geological storage in saline aquifers

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Objectives of PICOREF

Study the feasibility of a CO_2 storage project in geological reservoirs in France.

- Develop the French technological capacity
- Carry out the first storage pilot in France, preceding a storage at industrial scale
- Develop a methodology to assess CO_2 storage projects within the onshore French framework

A national project which brings together the main actors in the domain.

TOTAL

Gaz de France

géostock

AIR LIQUIDE

ALSTOM

LA SNET

Magnitude

CORREX

cfg services

icmcb

Ecole Nationale Supérieure des Mines SAINT-ETIENNE

LGIT Grenoble

LMT

INERIS INSTITUT NATIONAL DE L'ENVIRONNEMENT INDUSTRIEL ET DES RISQUES

Project leader

Géosciences pour une Terre durable brgm

Schedule of the project

- 2005-2007: **preliminary draft of the pilot**
- 2008: **documentation « request for storage authorization »**
- 2009: **implementation of the pilot**
- 2010-2015: **industrial demonstration**
- Post 2015: **industrial application (200 000 t/y during 10 years)**

PICOREF: preliminary draft of the pilot

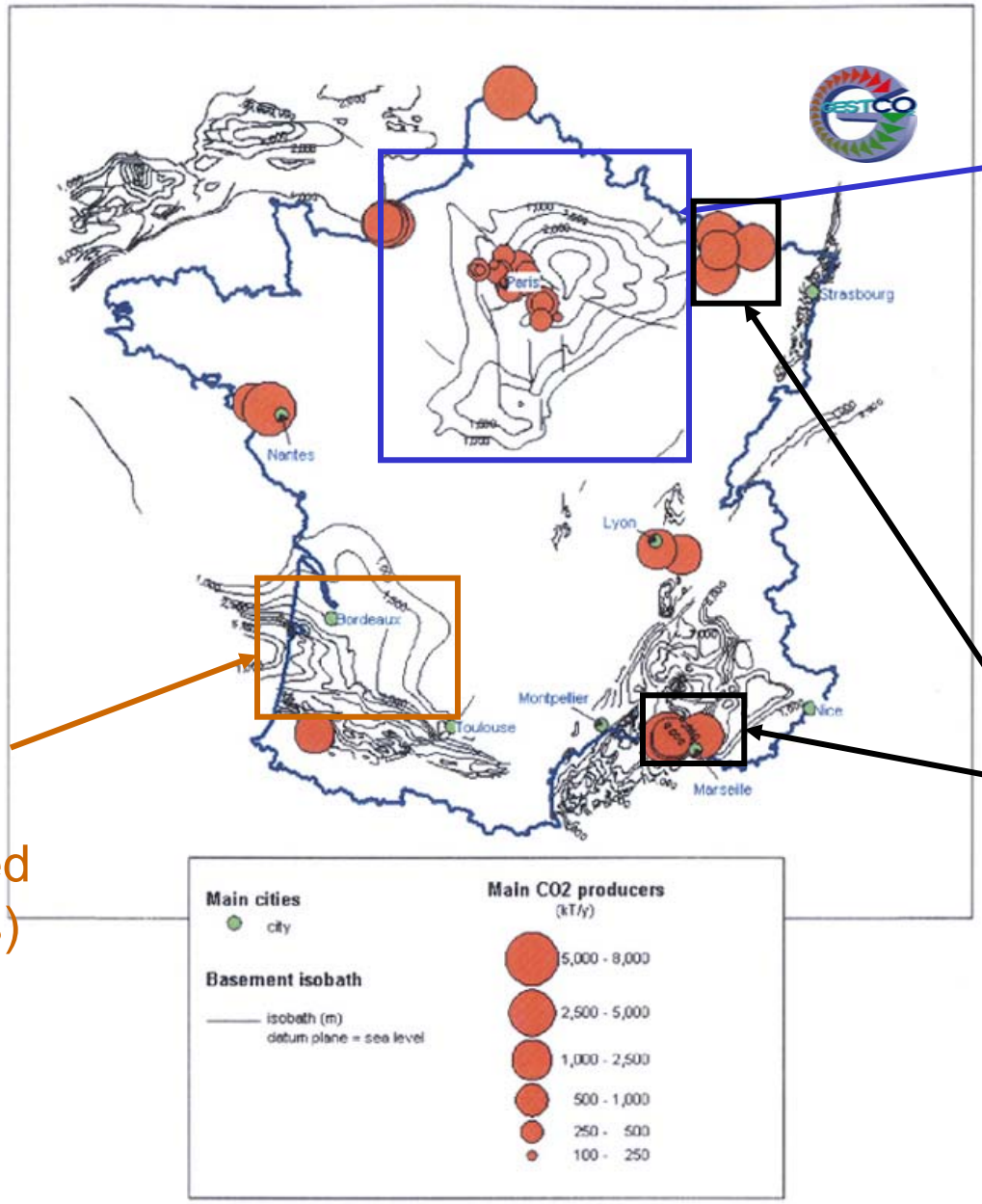
> 2 options

- Storage in depleted hydrocarbon fields
- Storage in deep saline aquifers

> Different workpackages

Selection of favourable areas for CO2 storage in geological reservoirs	Storage capacity assessment
Source to sink matching	Reservoir injectivity
Guaranty of integrity of the reservoir and its cap rock - methods development and design of dedicated tools	Safety of storage
Improve the modelling tools of the short and long term behaviour of the system Develop scenarios of risk assessment	

Main sedimentary basin in France

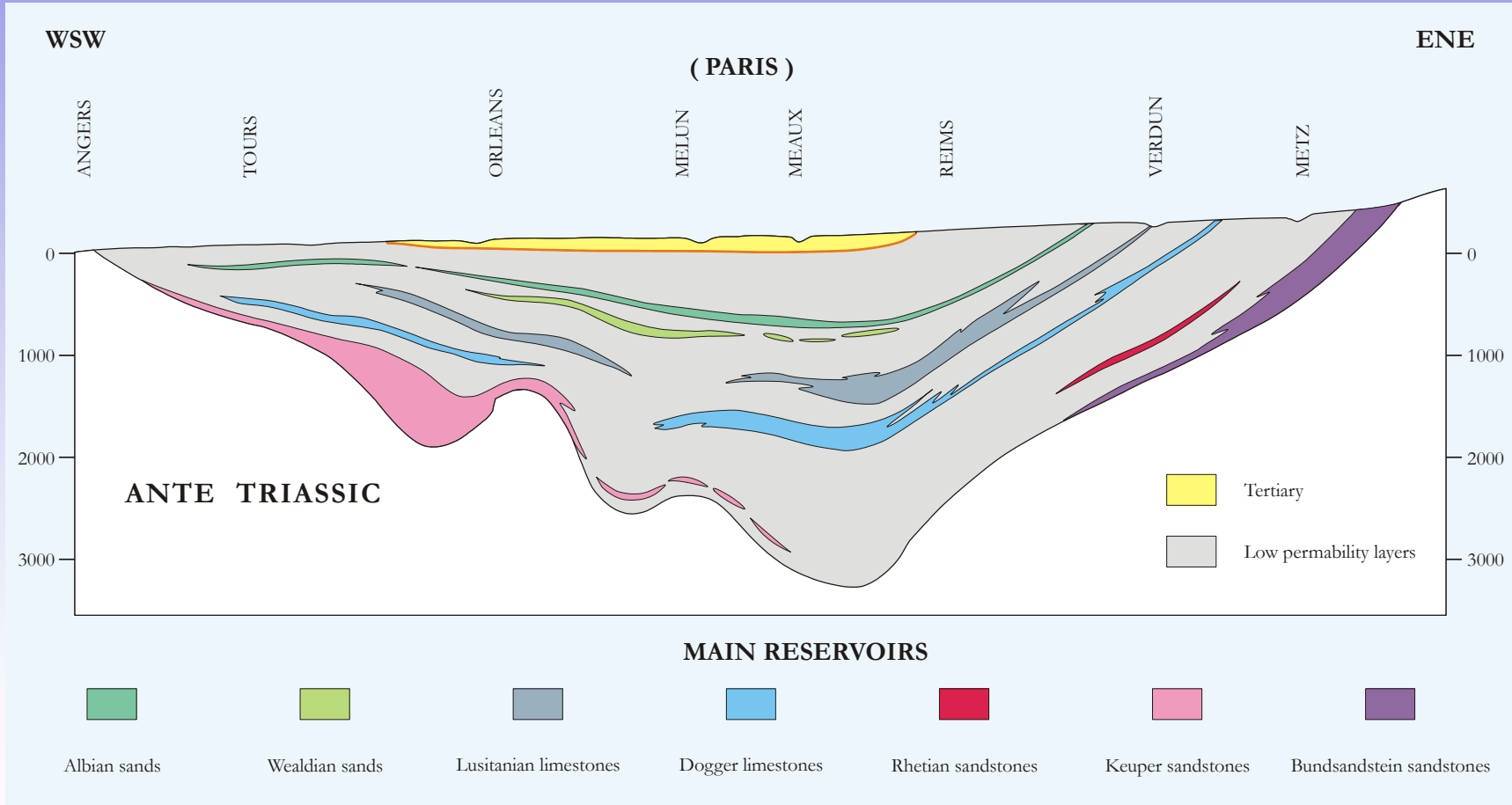


Paris Basin
(26 000 Mt in aquifers – 100 Mt in depleted fields)

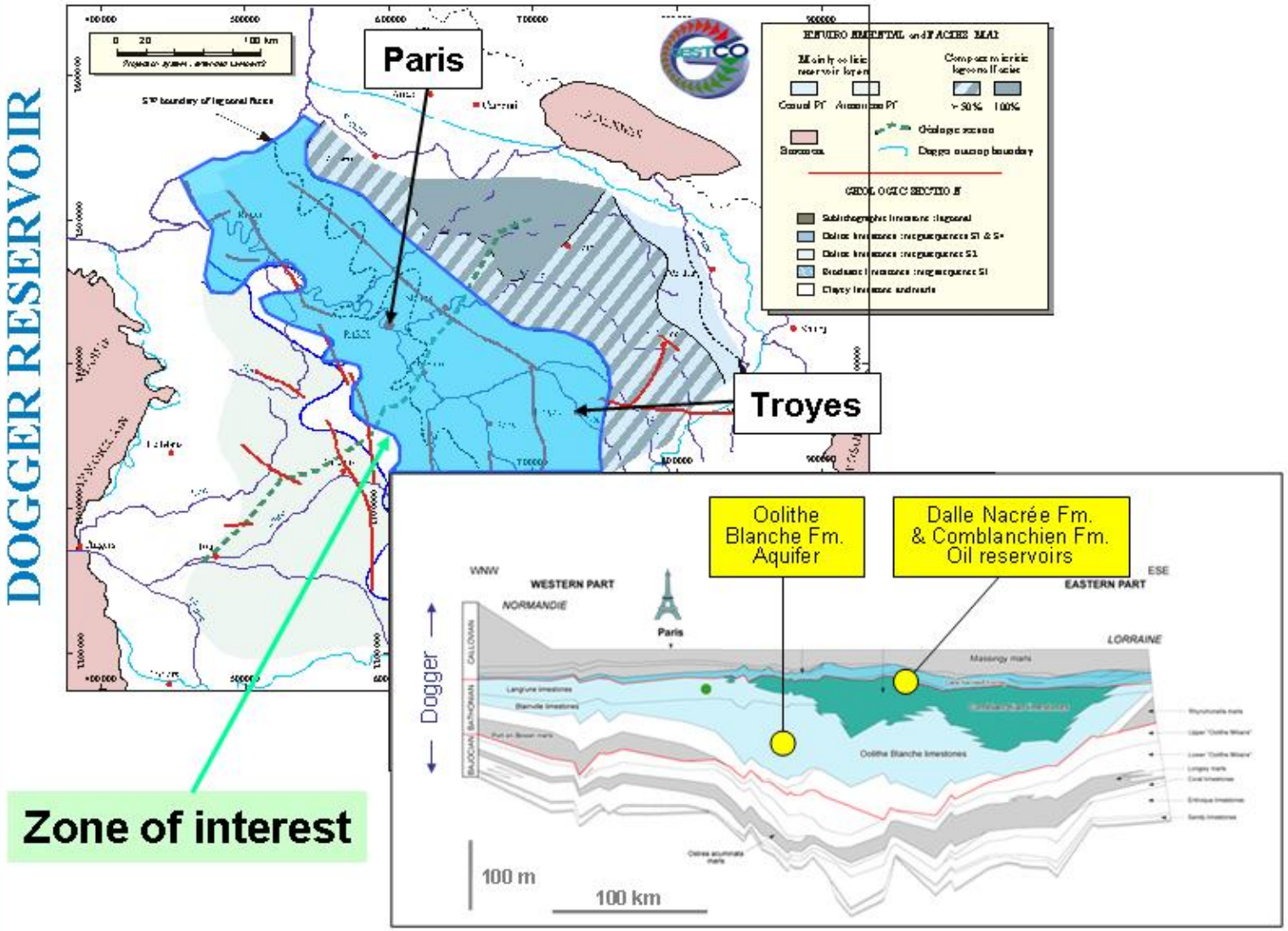
Aquitaine Basin
(? in aquifers
560 Mt in depleted oil and gas fields)

Coal-rich basins
(non evaluated)

Main reservoirs in the Paris Basin



The Dogger reservoir



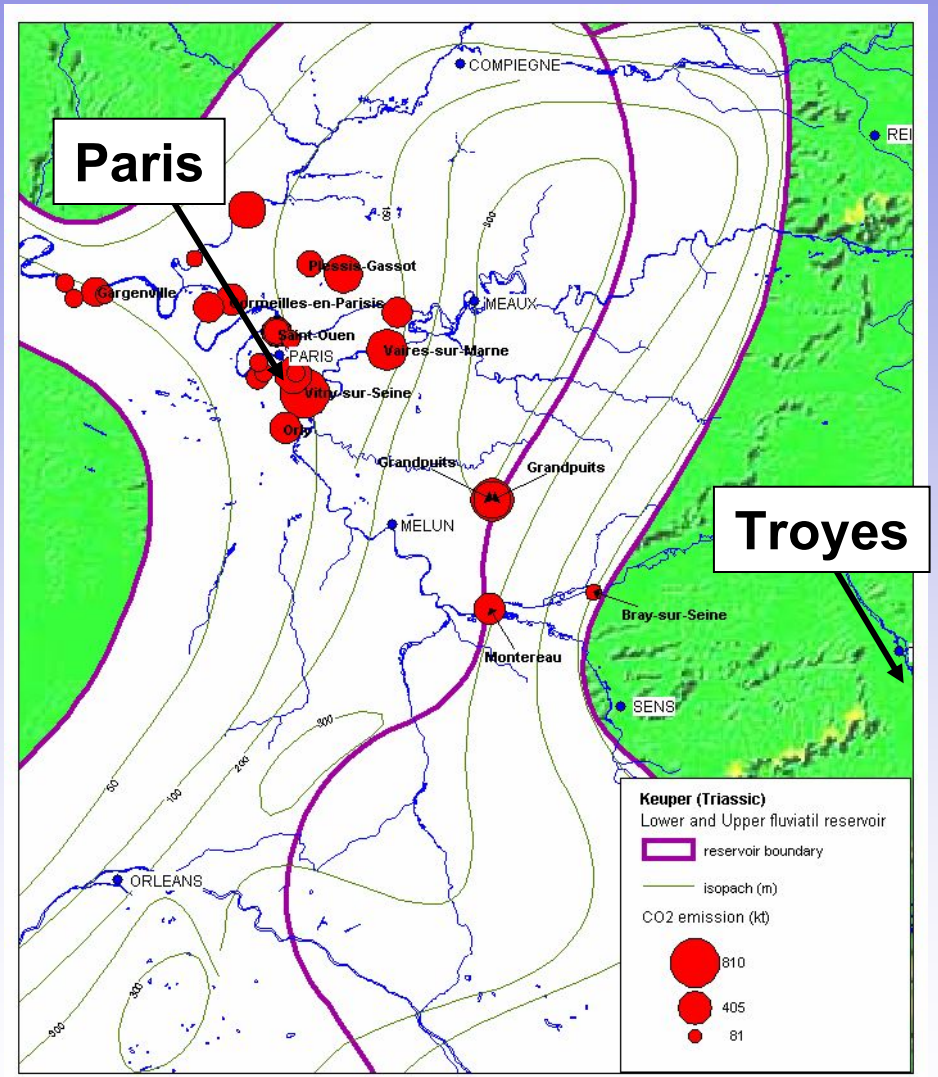
The Dogger reservoir

Geothermal plant for district heating
Le Mée sur Seine – Dogger

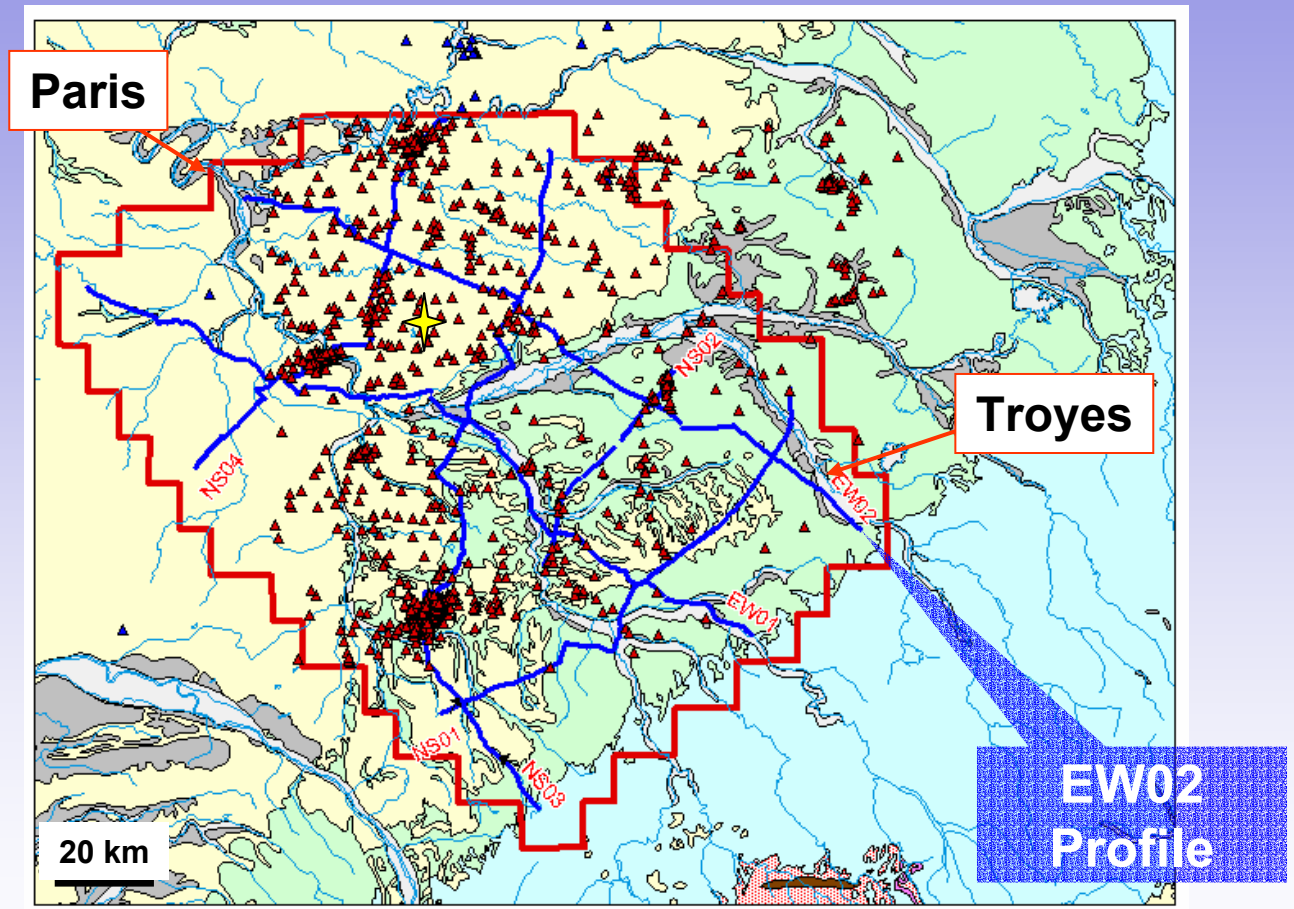
- **Geometry**
  - Reservoir depth (Dogger) = 1730 m
  - Thickness = 25 m
    (10 - 40 m for 5 to 20 layers)
- **Hydrodynamics**
  - Permeability = 1-2 D
  - Porosity = 16%
  - « Oolithe blanche » formation (50 - 75% of the total flow)
- **Fluids**
  - Temperature = 78°C
  - Salinity = 15-20 g/l
  - Pressure = 173.5 bar
- **Production conditions** (geothermal boreholes)
  - Maximum production = 250 m^3/h

The Keuper reservoir

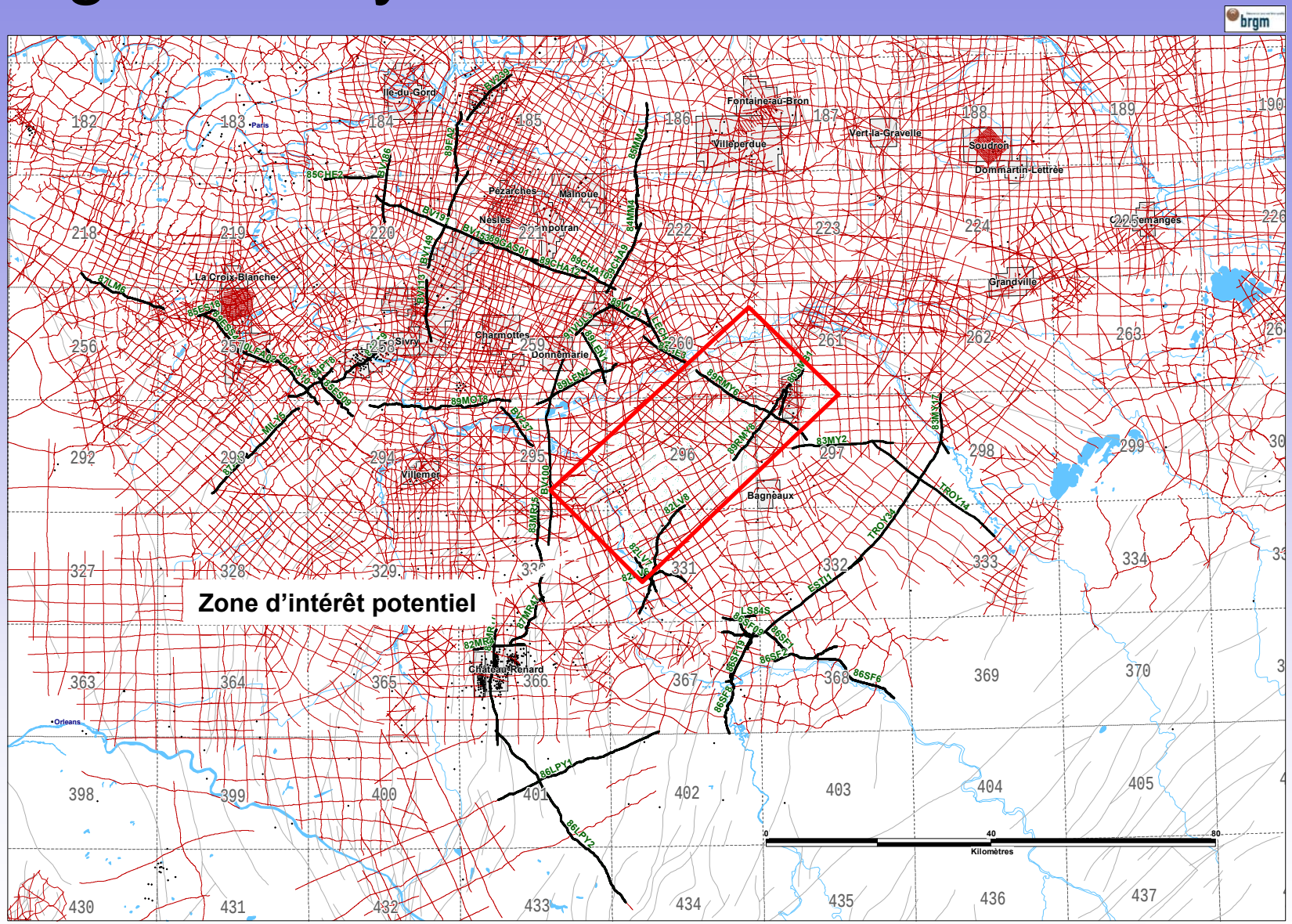
- **Geometry**
  - Reservoir depth (Keuper) = 2200 m
  - Thickness = 200 m
- **Hydrodynamics**
  - Permeability = 0.1 - 2.5 D
  - Porosity = 15 to 20%
- **Fluids**
  - Temperature = 100 - 110°C
  - Salinity = 80-100 g/l
  - Pressure = 220 bar



Existing data



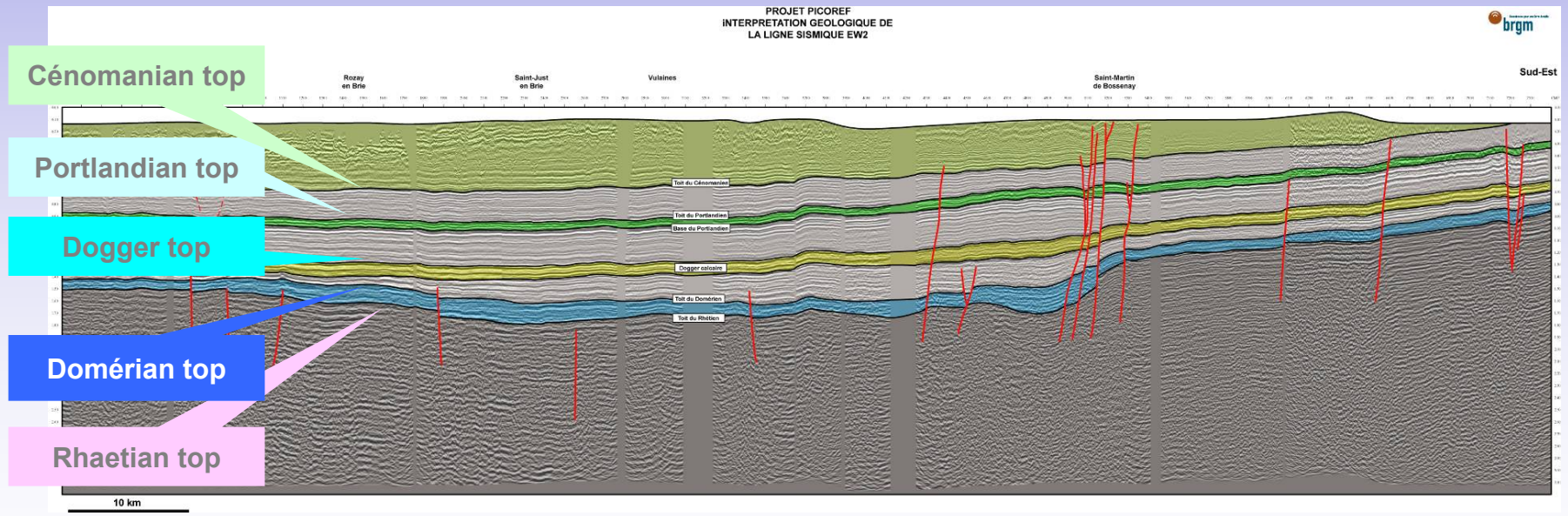
High density of seismic data



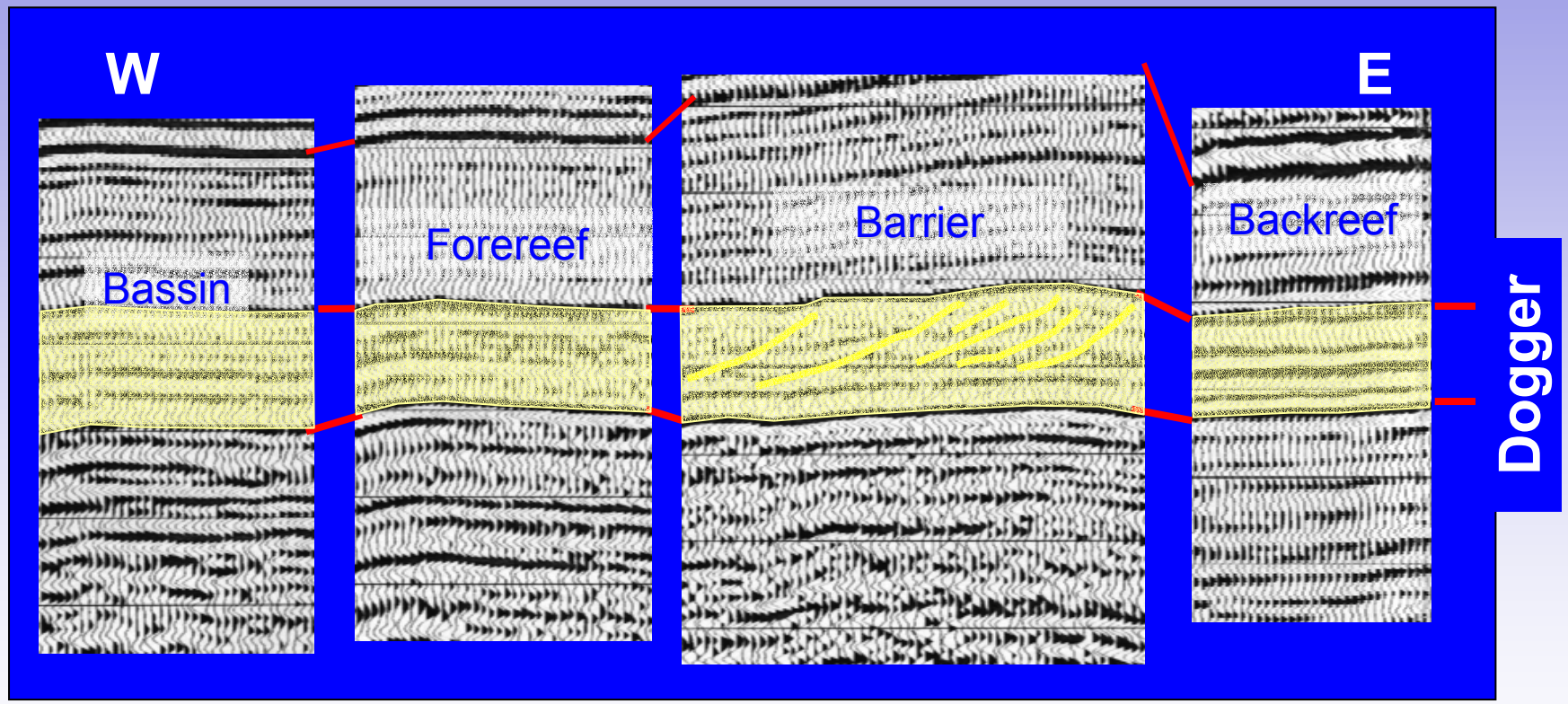
Seismic lines

- 740 km of seismic lines have been reprocessed
- Example of a regional transect (EW02 profile made of 13 sub-profiles)

Saint Martin de Bossenay fault

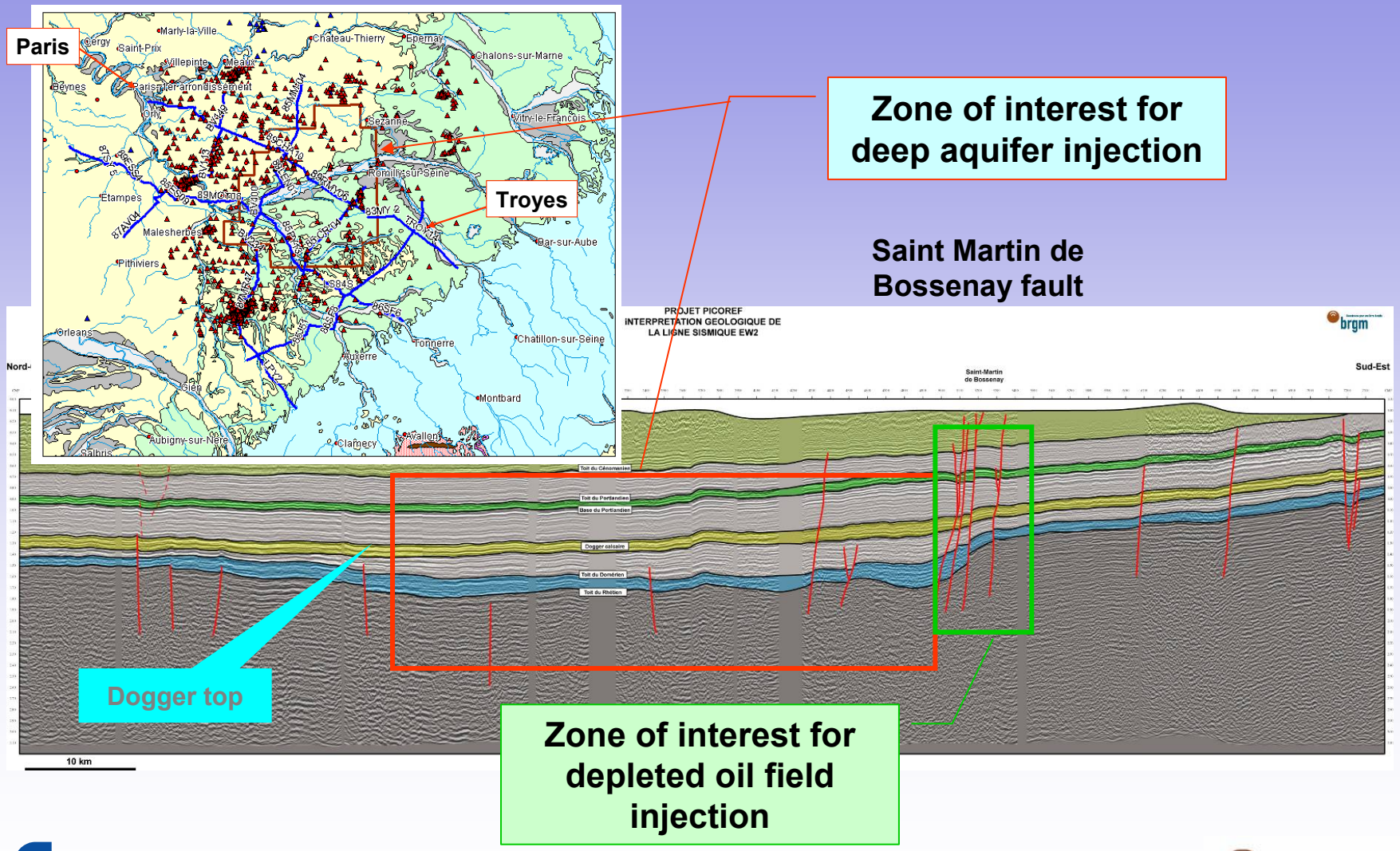


Seismic stratigraphy

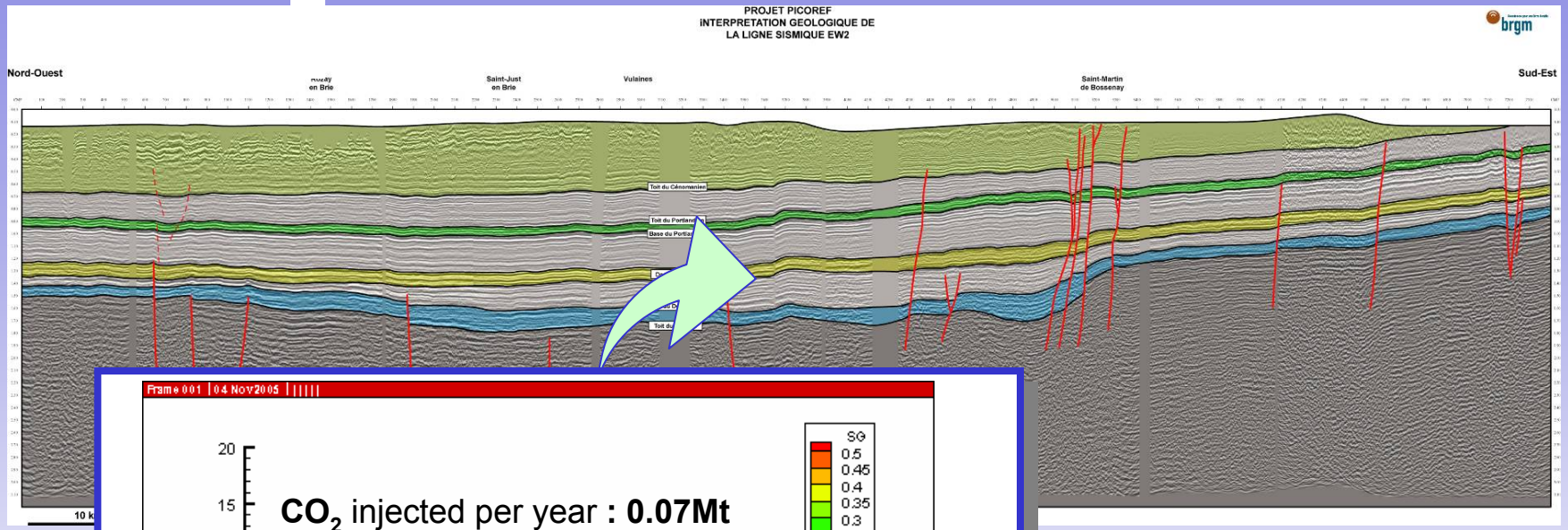


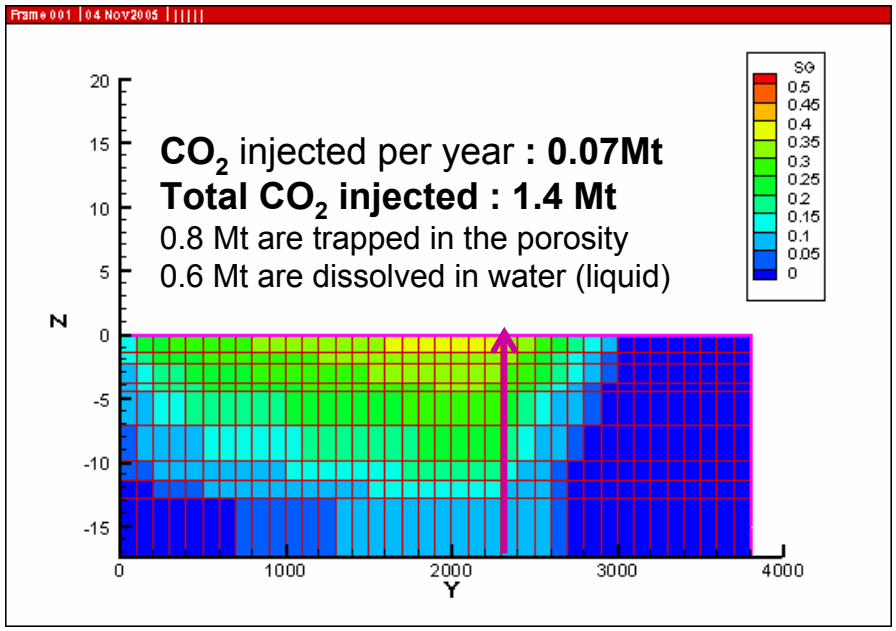
Dogger facies along the EW02 regional transect

Pre-selected areas for CO_2 storage



Fluid flow modelling





CO_2 injected per year **: 0.07Mt**
Total CO_2 injected : 1.4 Mt
0.8 Mt are trapped in the porosity
0.6 Mt are dissolved in water (liquid)

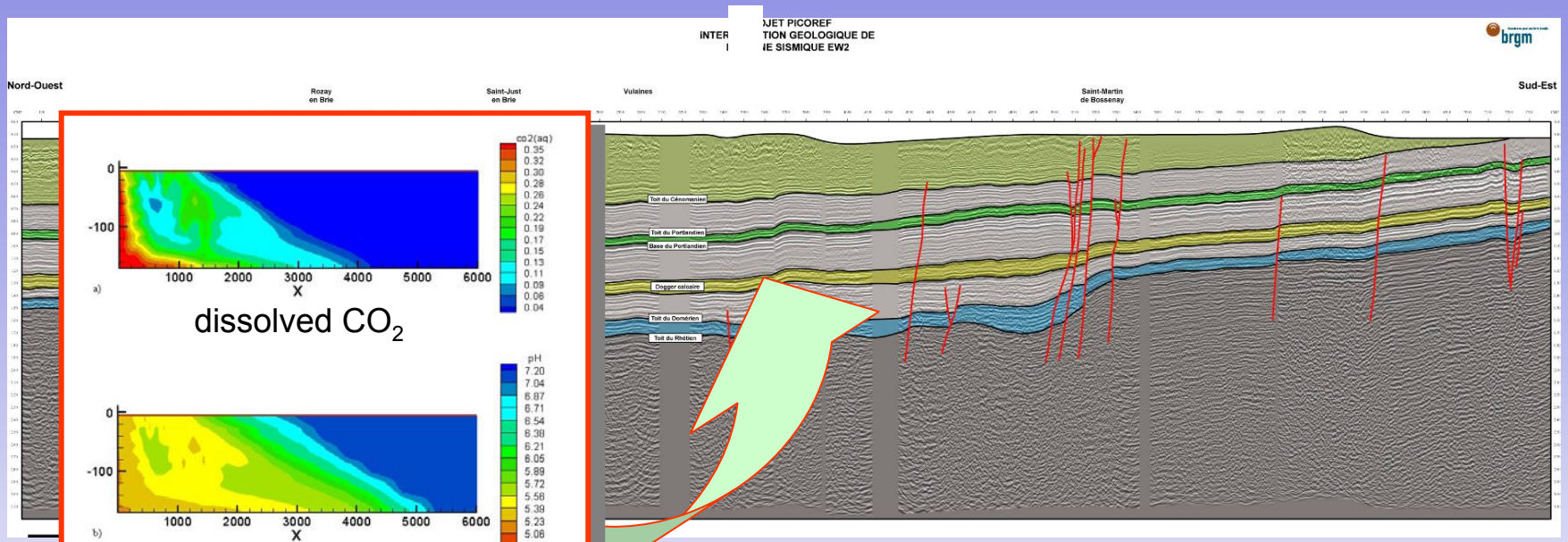
Toughreact: simulation program for chemically reactive non-isothermal flows of multiphase fluids

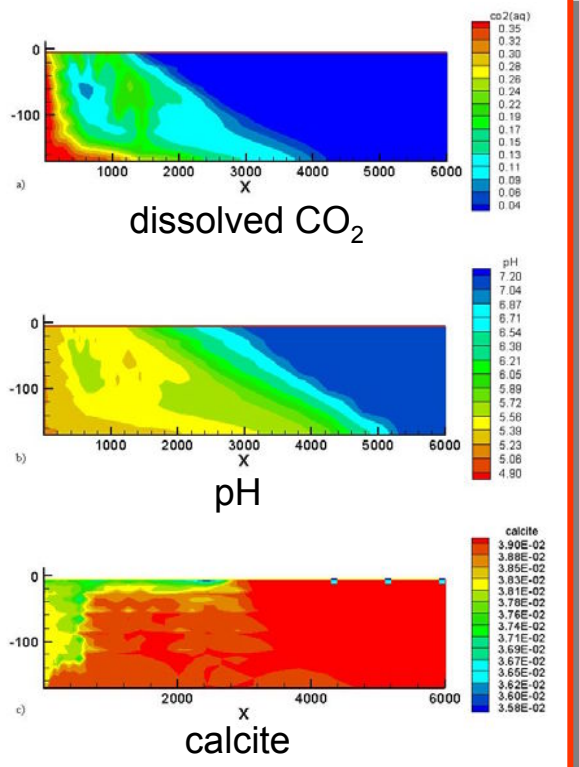
50 years

-Injectivity
-Solubilization
-Capacity/injection

Constant pressure at left
Reservoir dip : 1° E
Water flow : 1m/y (E→W)
$C0_2$ injected : 2.2 kg/s
Duration : 20 years

Water-rock interactions modelling





Simulation with **Toughreact**

Reservoir (ex. Utsira)
after 10,000 years

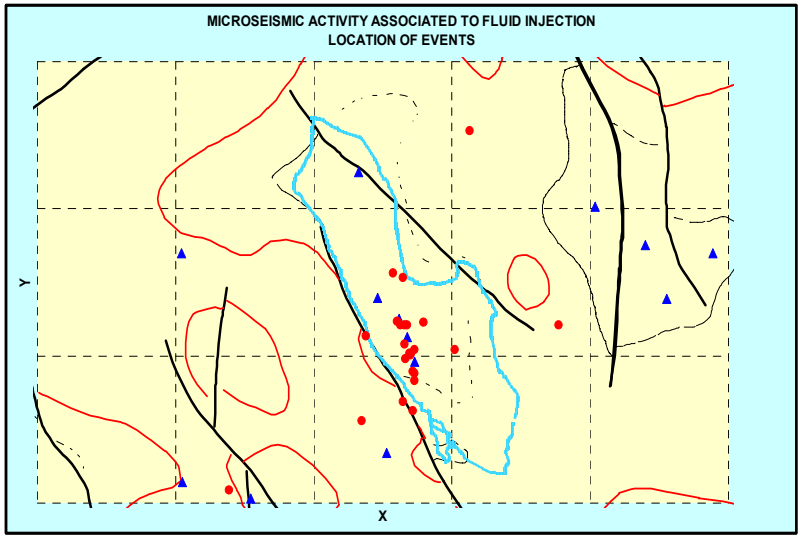
Long term forecast of the storage behaviour

-Forecast of CO_2 dissolution
-Acidification of the aquifer
-Mineral dissolution and precipitation
-Mechanical behaviour of the cap rock

Monitoring design

- Prior to HSE impacts at the surface, the main concern is the protection of the Albian aquifer (drinking water strategic reserve at 800-900 m depth)
- Ongoing previous modelling to design the 4 D seismic monitoring
- Development of tools for downhole gas and fluid measurements
- Well monitoring (injection & Observation)
- Microseismicity monitoring
- Feasibility of gravity and electric/EM methods
- Etc.

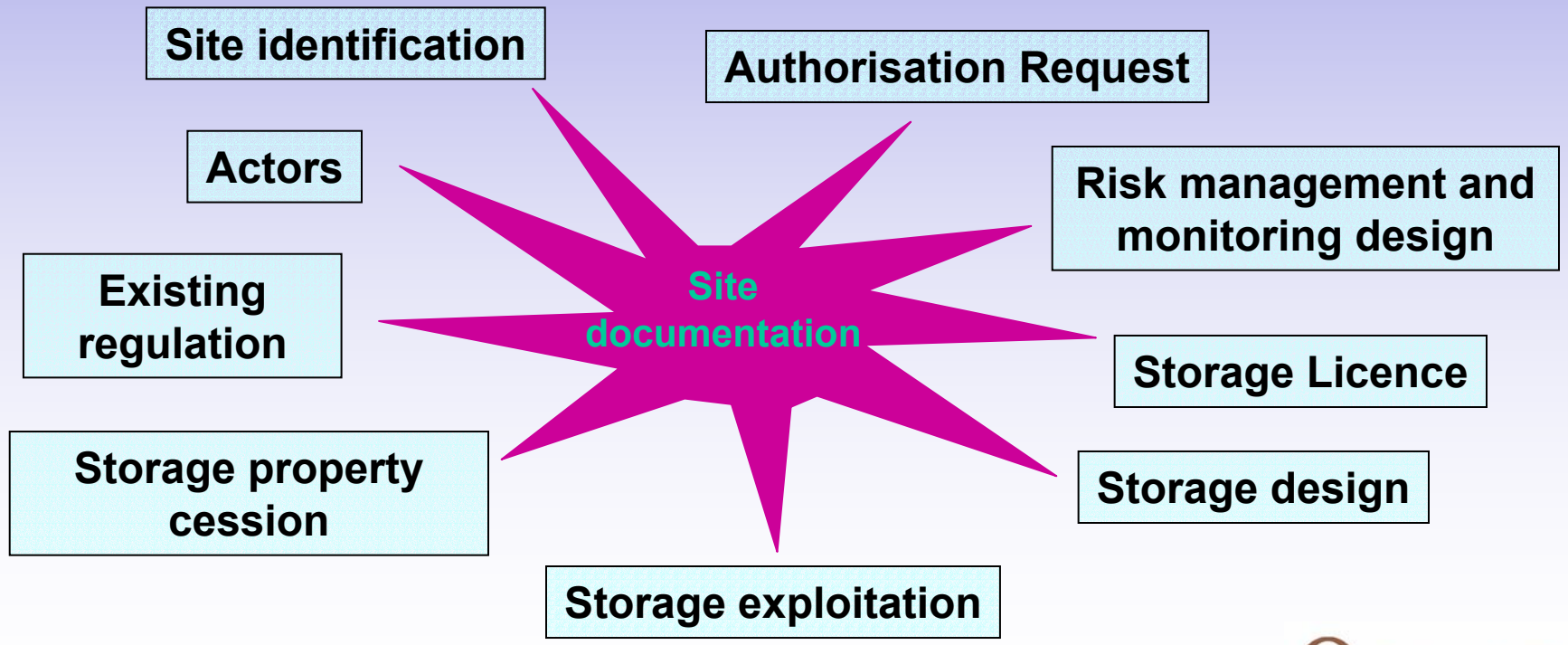
Example of short-mid term monitoring: passive seismic



Elaboration of the “site document”

MINISTÈRE DE L'ÉCONOMIE
DES FINANCES ET DE L'INDUSTRIE

It shall have to identify all the parameters and data that are requested by the existing regulation but also the critical points that must be taken into account and integrated by the new regulation



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Conclusions

All the works conducted from 2005 to 2007 will allow us to:

- confirm the interest of the sites selected for the implantation of the future pilot
- prepare the storage operating conditions (design, modelling, monitoring, risk management)
- help the Administration to adapt the French regulation to the particular case of CO_2 long-term storage