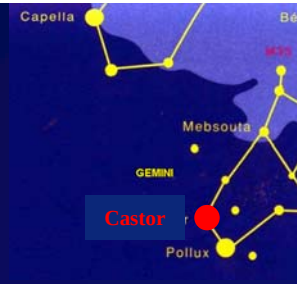


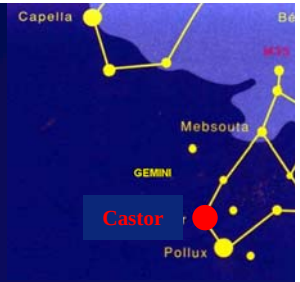
CASTOR

CO_2, from Capture to Storage

an European Initiative

Pierre Le Thiez
Project Manager CCS, IFP, France

Presentation outline

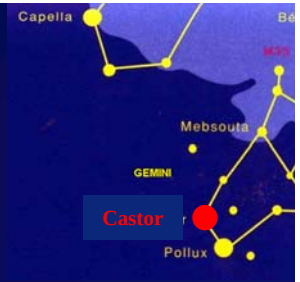


- Castor at a glance
- Post-combustion capture
- CO_2 geological storage
- The way forward

CASTOR at a glance

- Objectives:
  - Reduce the cost of CO_2 post-combustion capture
  - Contribute to the feasibility & acceptance of the geological storage concept
  - Validate the concept on real site(s)
    - Pilot testing for capture (1 t CO_2 / hour)
    - Detailed studies of future storage projects
- Funded by the European Commission under the 6th Framework Programme

CASTOR at a Glance (2)



R&D	Oil & Gas	Power Companies	Manufacturers
IFP (FR)	STATOIL (NO)	VATTENFALL (SE)	ALSTOM POWER (FR)
TNO (NL)	GDF (FR)	ELSAM (DK)	MITSUI BABCOCK (UK)
SINTEF (NO)	REPSOL (SP)	ENERGI E2 (DK)	SIEMENS (DE)
NTNU (NO)	ENITecnologie (IT)	RWE (DE)	BASF (DE)
BGS (UK)	ROHOEL (AT)	PPC (GR)	GVS (IT)
BGR (DE)		POWERGEN (UK)	
BRGM (FR)			
GEUS (DK)			
IMPERIAL (UK)			
OGS (IT)			
TWENTE U. (NL)			
STUTTGARTT U. (DE)			

Co-ordinator: IFP

Chair of the Executive Board: Statoil

30 partners from 11 European Countries

Budget: 15,8 M€

EU funding: 8,5 M€

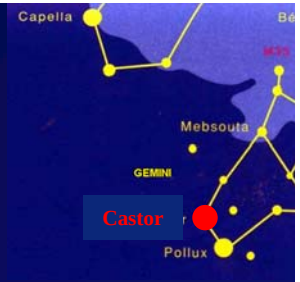
Industrial funding: 2,2 M€

Duration: 4 years

CASTOR at glance (3)

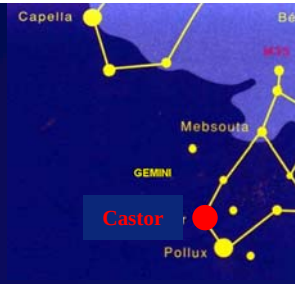
- Kick-off in February 2004
- Recognised by the Carbon Sequestration Leadership Forum, Melbourne, Australia, Sept. 2004

Post-combustion capture



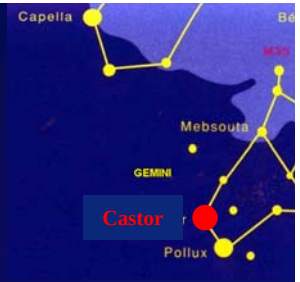
- Objectives
  - Development of absorption liquids, with a thermal energy consumption of 2.0 GJ/tonne CO_2 at 90% recovery rates
  - Resulting costs per tonne CO_2 avoided not higher than 20 to 30 €/tonne CO_2, depending on the type of fuel (natural gas, coal, lignite)
  - Pilot plant tests showing the reliability and efficiency of the post-combustion capture process

Issues for flue-gas CO_2-capture technology



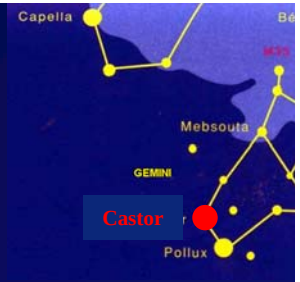
- Absorption technology is leading option but:
  - Power cost increases >50%
  - Generation efficiency decreases by 15 – 25%
- Absorption process breakthroughs required
  - Energy consumption
  - Reaction rates
  - Contactor improvements
  - Liquid capacities
  - Chemical stability/corrosion
  - Desorption process improvements
  - Hence cost reductions
- Integration with power plant
  - Heat integration with other process plant, particularly in relation to desorption process

Major technical results/deliverables



- New solvents resulting in less heat for regeneration
- Advanced processes resulting in lower power output losses
- Advanced equipment (membrane contactors) resulting in lower investment costs
- Pilot plant operating with real flue gas allowing hands-on-experience with absorption technology
- Methods for integration and optimisation resulting in lower power output losses

European post-combustion test facility



Capacity: 1 t CO_2 / h

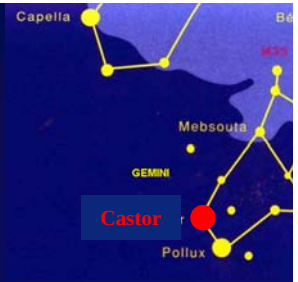
5000 Nm3/h fluegas (coal combustion)

In operation early 2006

The greatest post-combustion pilot worldwide

Official Pilot Launching 15th March 2006

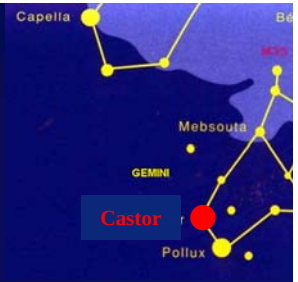
CO_2 geological storage



No capture without storage!

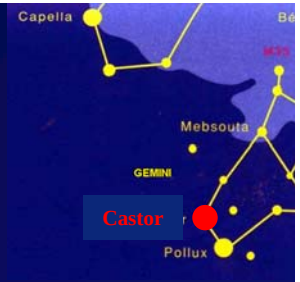
- Objectives
  - Develop and apply a methodology for the selection and the secure management of storage sites by improving assessment methods, defining acceptance criteria, and developing a strategy for safety-focussed, cost-effective site monitoring
  - Improve the "Best Practice Manual" by adding 4 more real-site cases

CO_2 geological storage



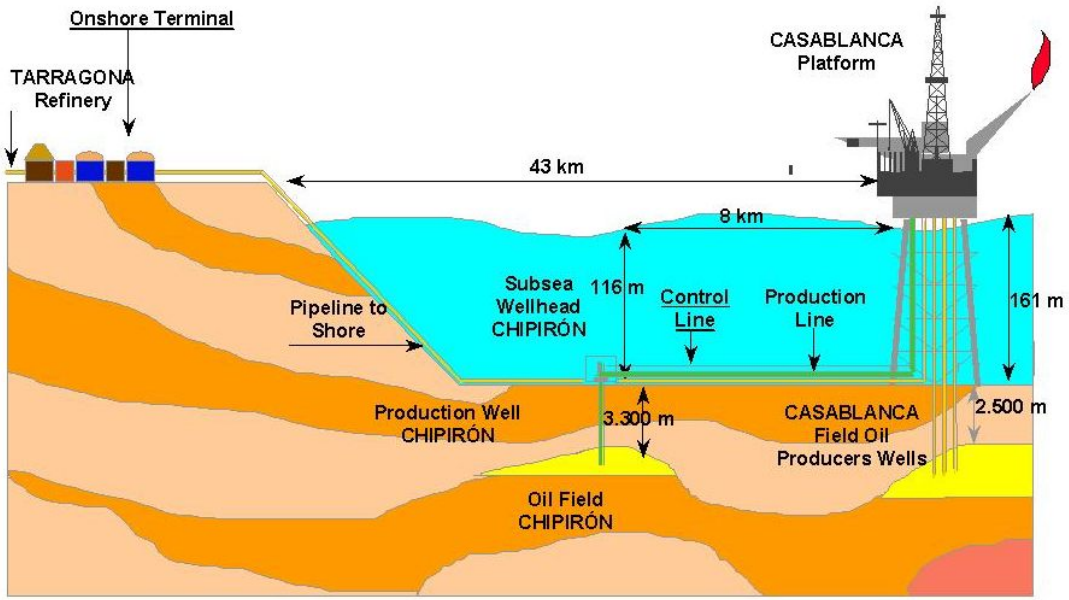
- Four field cases to cover some geological variability:
  - clastics (sandstones) vs. carbonates
  - onshore vs offshore (consequences for monitoring)
  - storage site types: depleted oil field, depleted gas field, enhanced gas recovery, aquifer
  - some cases with good sample access, others with chance for monitoring
    (→ covers many methods, focus different from field to field)
  - cases in different countries to give many countries their 'own case' (good for public acceptance)
- Two cross-disciplinary activities
  - Preventive and corrective actions
  - Criteria for site selection & site mgmt

Casablanca oilfield (Repsol, Spain)

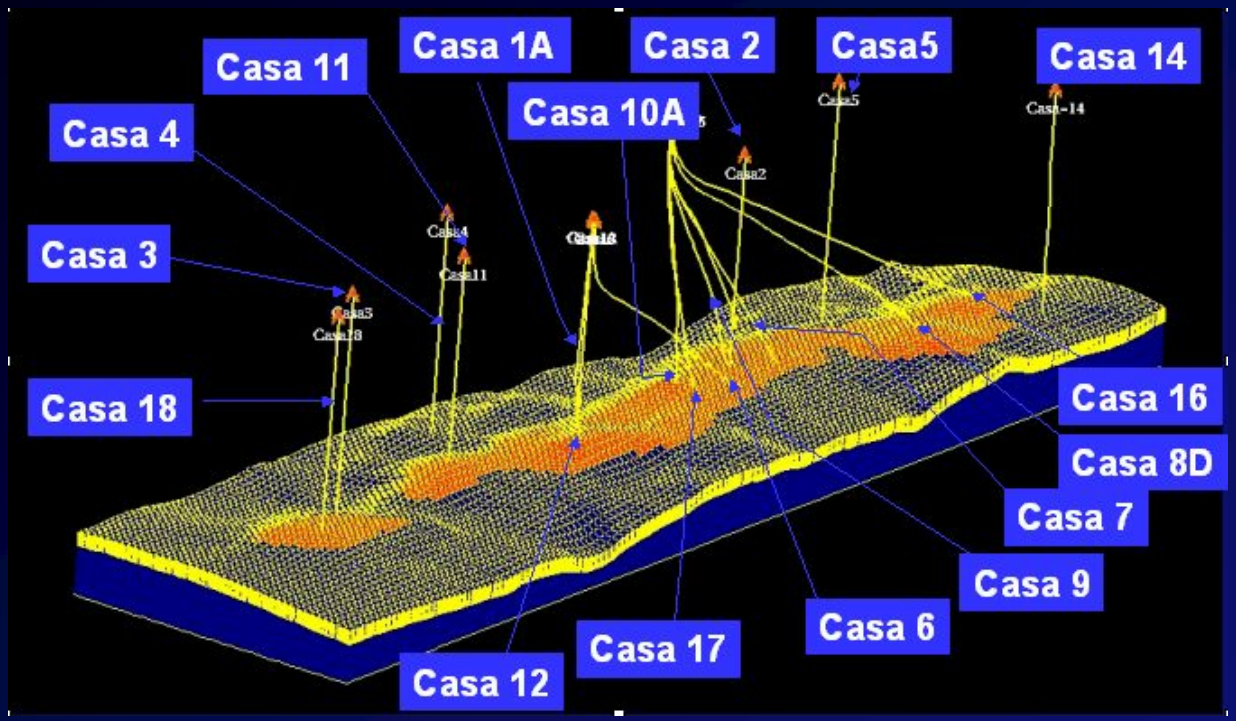


- **Depleted oil-field in carbonates**
- **Depth: 2500 m**
- **Injection of 0,5 Mt CO_2 / year from the Tarragona Refinery**

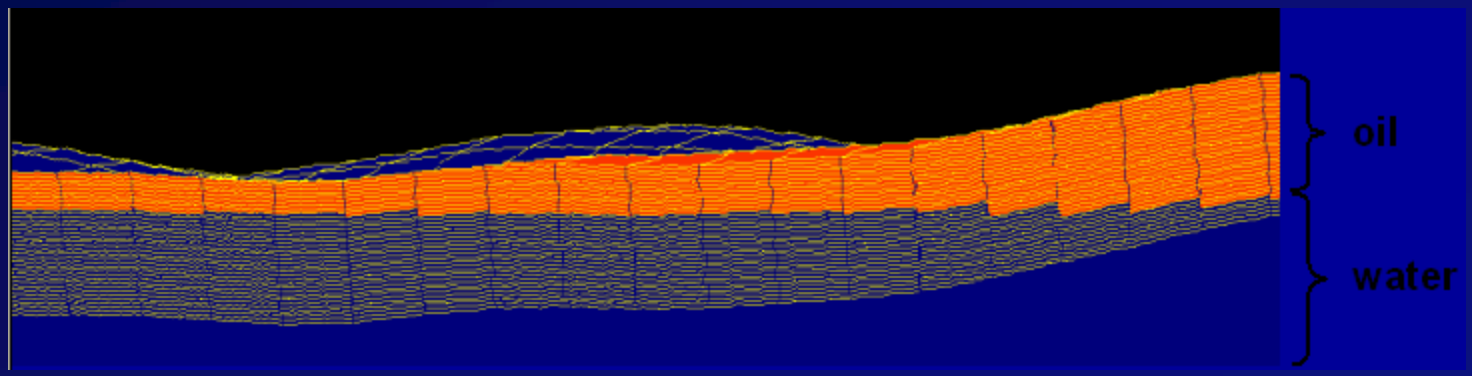
repsolypf.com



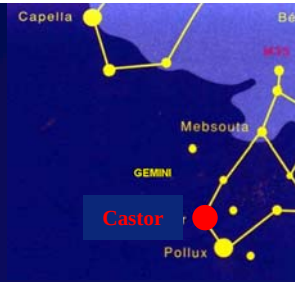
Casablanca oilfield (Repsol, Spain)



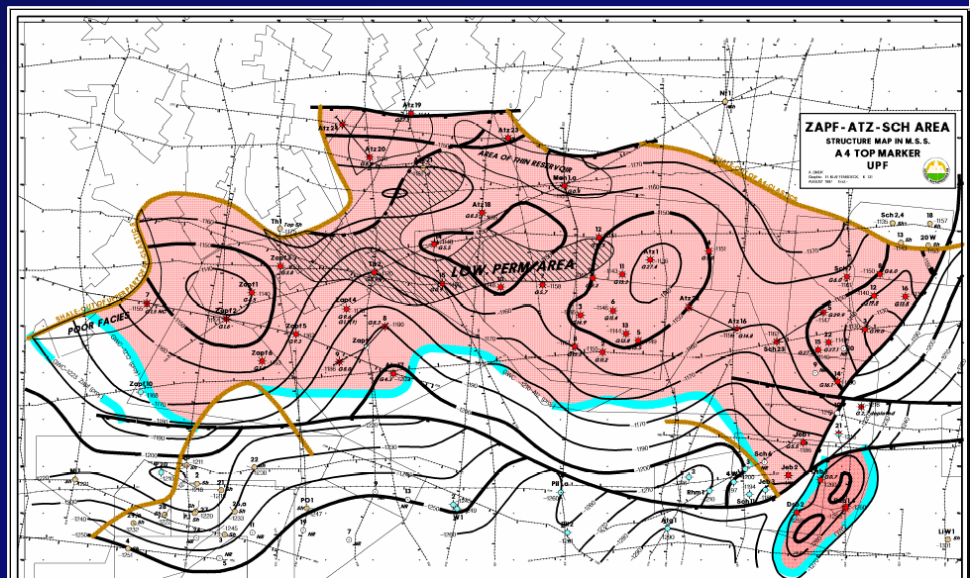
Focus: general storage site evaluation; geochemical reactions with carbonates; less on safety and monitoring



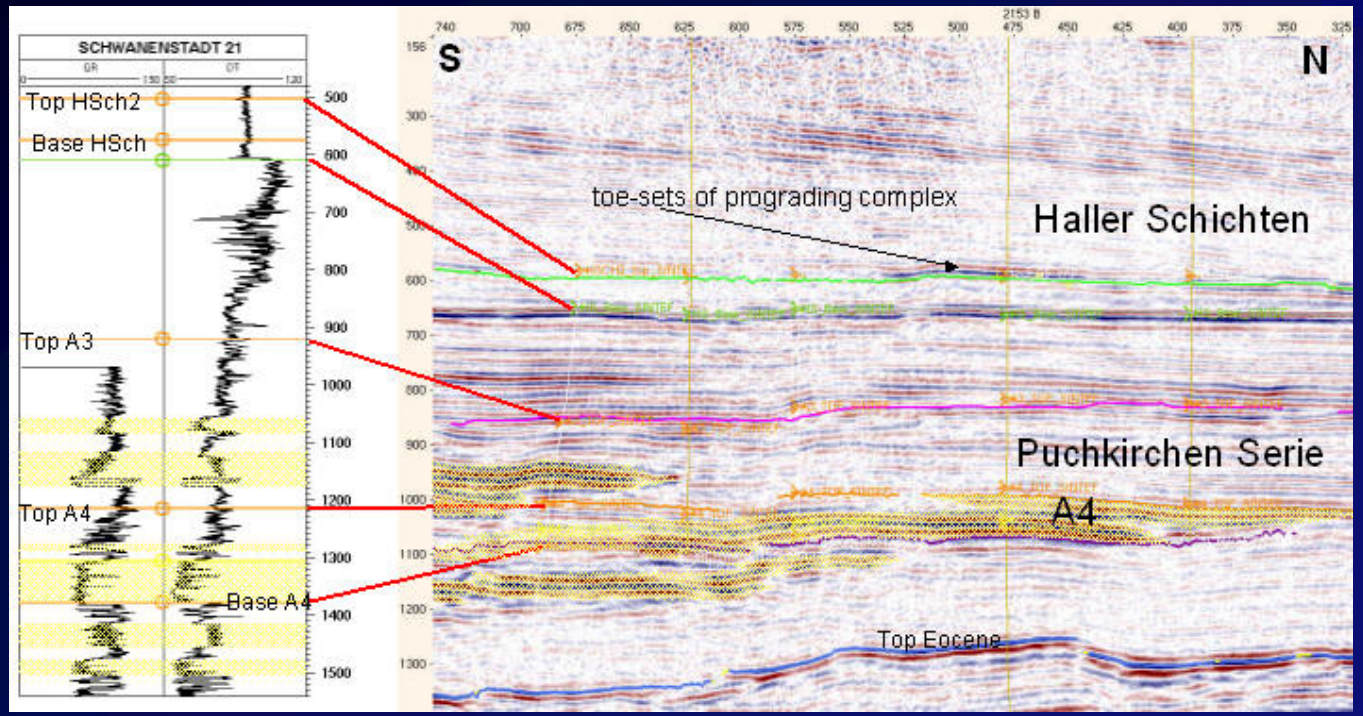
Atzbach-Schwanenstadt Gas Field (Rohoel, Austria)



- **Sandstone gasfield, onshore**
- **Depth: 1600 m**
- **Possible injection of 200,000 t CO_2/year**
- **Opportunity for EGR**



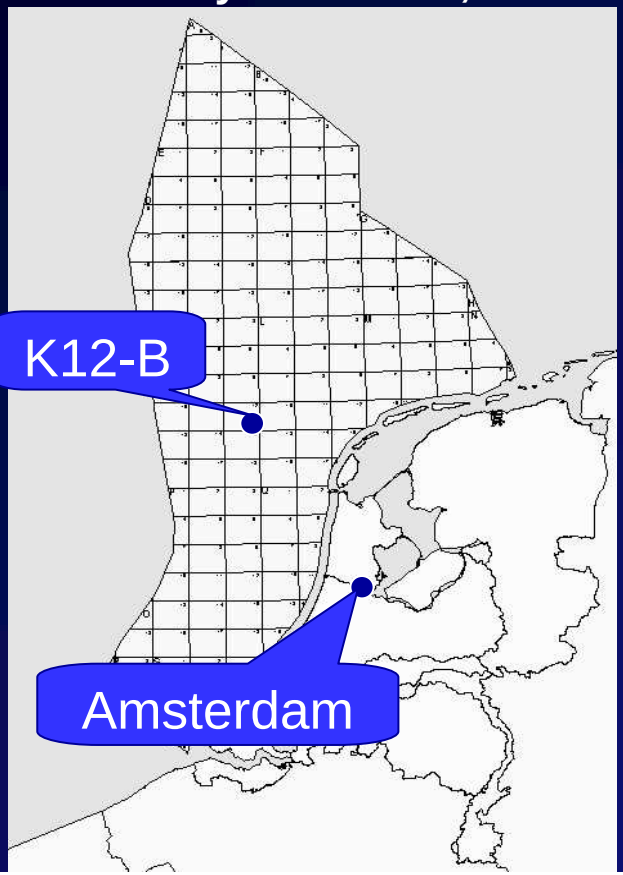
Atzbach-Schwanenstadt Gas Field (Rohoel, Austria)

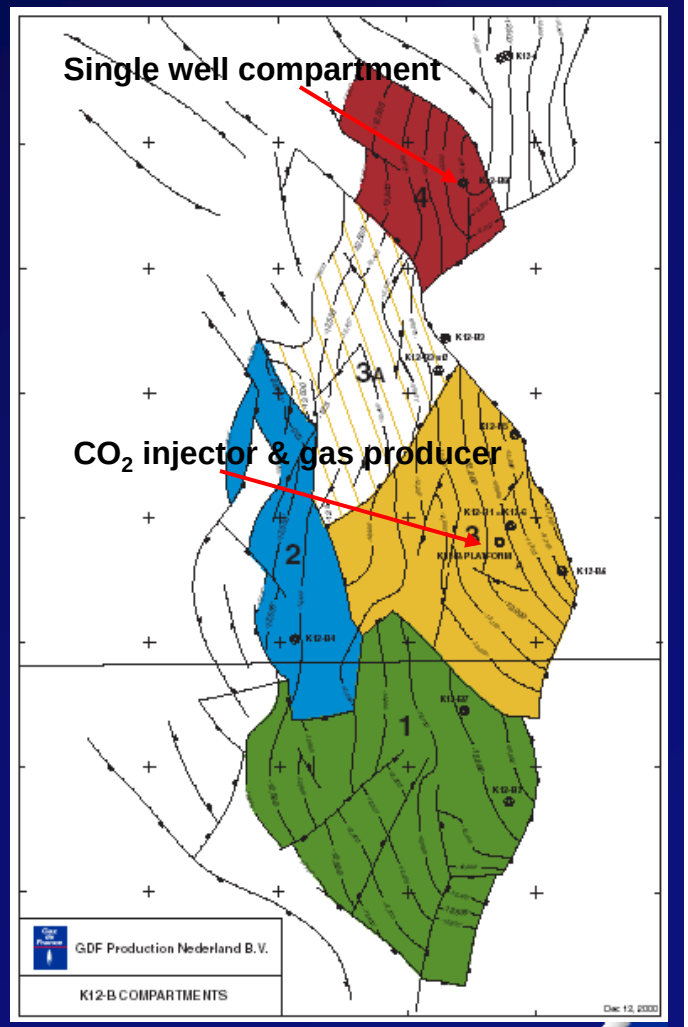


Focus: general storage site evaluation; seal properties (fluid flow, geochemistry, geomechanics); long-term safety / risk assessment; onshore monitoring methods; assessment of possibilities for enhanced gas recovery

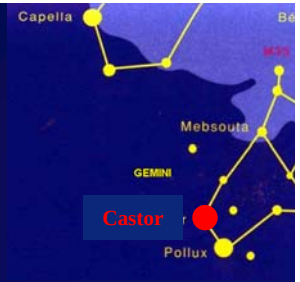
K12B Gas Field (Gaz de France, The Netherlands)

- Gasfield in Rotliengen clastics, offshore
- Depth: 3500-4000 m
- High temperature: 128 °C, low pressure: 40 bars
- Small-scale injection test: 20 000 t/year in mid-2004
- 480 000 t/year in 2006, 8 Mt total





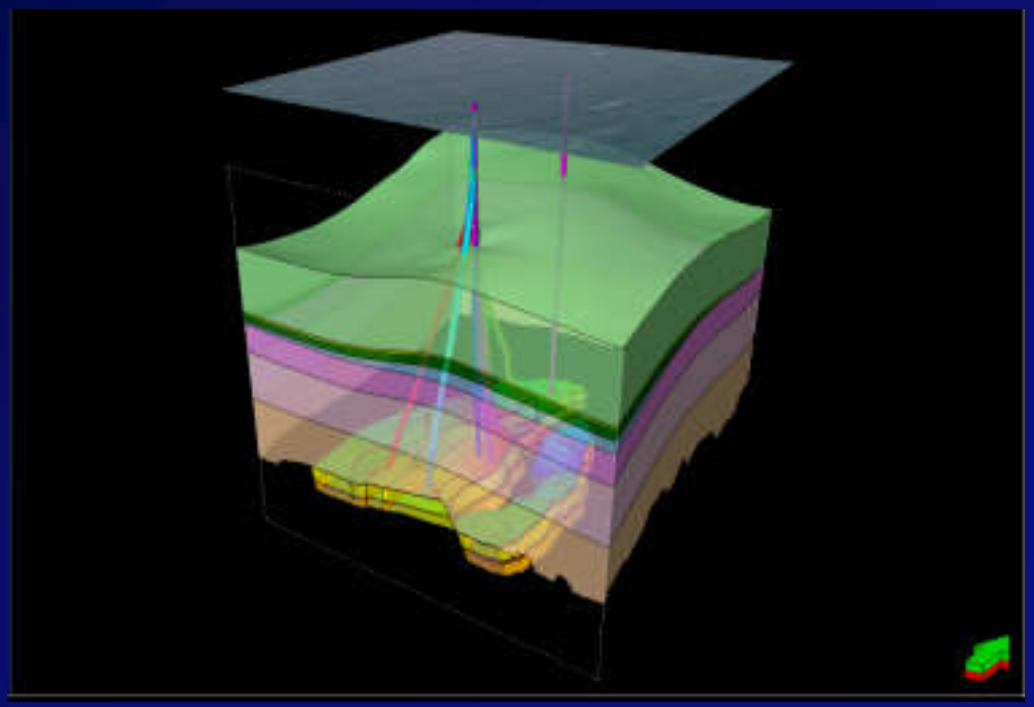
K12B Gas Field (Gaz de France, The Netherlands)



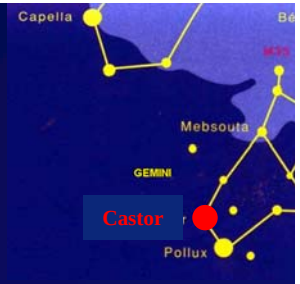
Focus: general storage site evaluation; long-term safety, monitoring (seismics).

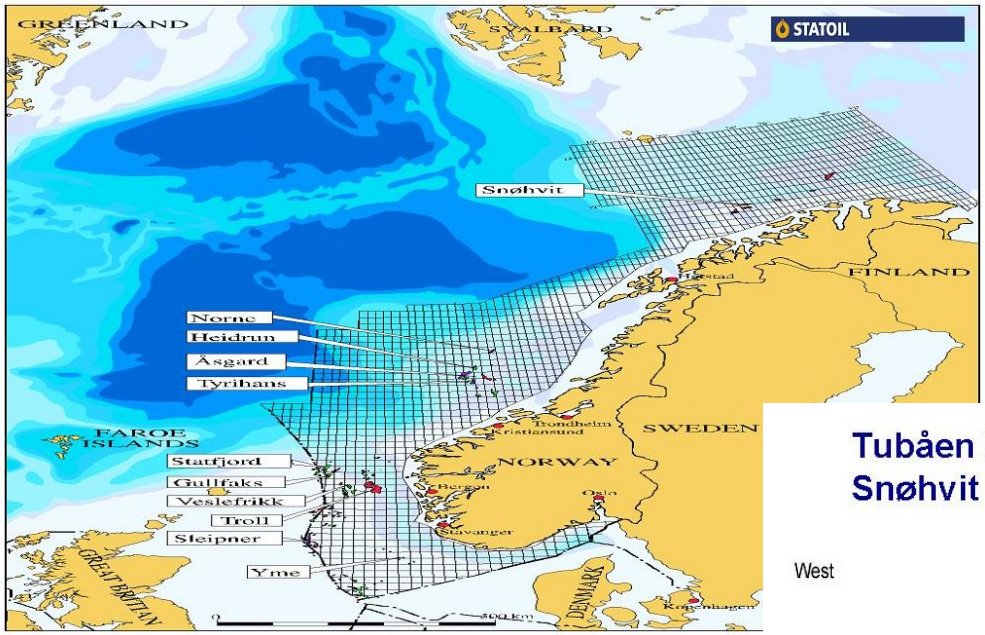
Improved geological model
- Facies model was established
- 3D seismic interpretation for the K12B field
- Petrophysical log analysis on all K12B wells

Experimental work
- Core material of Rotliegen reservoir and Zechstein seal gathered and sent to BGR and BGS
- Preparation of samples for experiments started



Snohvit Aquifer (Statoil, Norway)

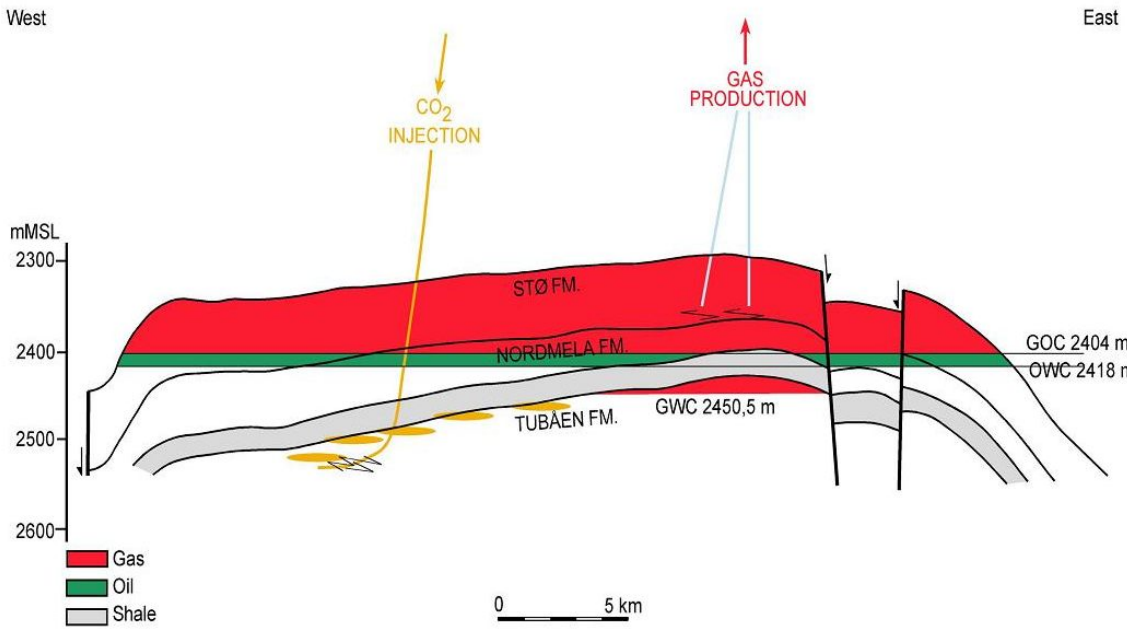




- Sandstone aquifer, offshore
- Depth: 2500 m
- 0.75 Mt CO_2 per year; Start in 2006 and last for 20 + years
- CO_2 source is removal from natural gas before cooling to LNG; limit 50 ppmvol.

Tubåen Formation storing CO2 under the Snøhvit Field

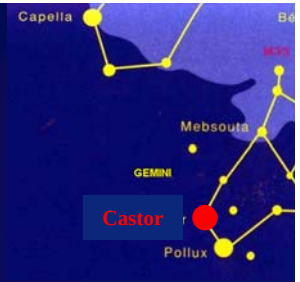
STATOIL



STATOIL

Focus: Well integrity, Injectivity, Monitoring

CASTOR the way forward



- CASTOR is a large integrated effort aiming at:
  - Developing technologies for cost-effective post-combustion capture (pilot plant launching beginning of 2006, official launching 15th March 2006)
  - Building confidence in CO_2 geological storage by adding 4 more cases to the portfolio of existing sites:
    - K12B in the Netherlands: industrial scale in 2006
    - Start CO_2 injection on Snohvit in 2006