Sixth Annual Conference on Carbon Capture & Sequestration

CCS Outside the U.S.

The CASTOR Project (CO_2 from Capture to Storage) - Major Achievements and the Way Forward

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Presentation outline

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

CASTOR targets

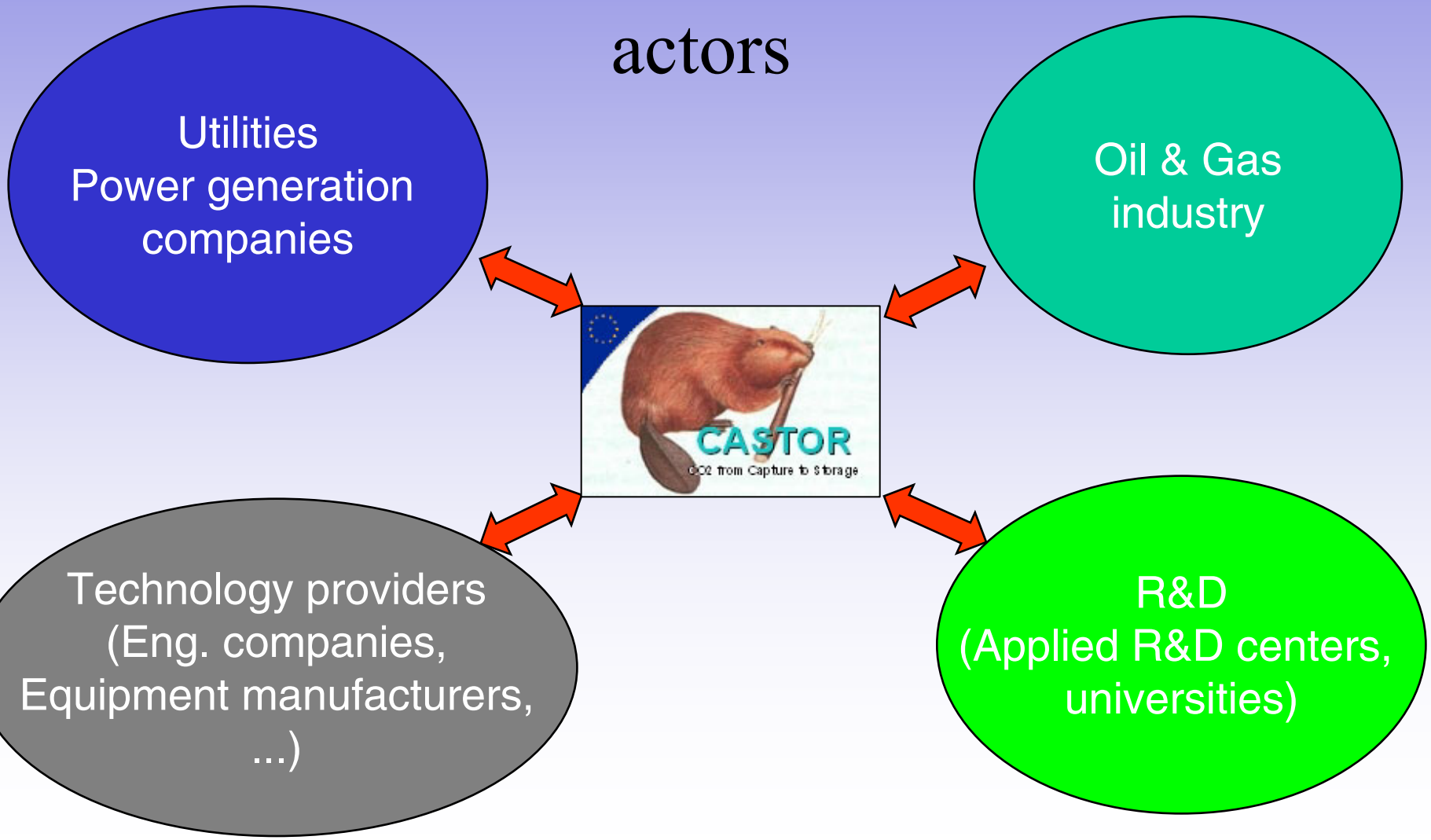
- Develop and validate innovative technologies needed to capture 10% of CO_2 emitted in Europe (30% of CO_2 emitted by power and industrial plants)
  - Reduce the cost of CO_2 post-combustion capture,

    $\Rightarrow$ *from 50-60 € to 20-30 € / ton of CO_2 avoided*
  - Contribute to the feasibility & acceptance of the geological storage concept

    $\Rightarrow$ *study 4 new European storage sites*
  - Start the development of an integrated strategy connecting capture, transport and storage options for Europe

CASTOR at a Glance (2)

A wide representation of European actors



CASTOR at a Glance (2)

Funded by the European Commission under the 6th Framework Program

R&D	Oil & Gas	Power Companies	Manufacturers
IFP (FR)	STATOIL (NO)	VATTENFALL (SE, DK)	ALSTOM POWER (FR)
TNO (NL)	GDF (FR)	DONG ENRGY (DK)	MITSUI BABCOCK (UK)
SINTEF (NO)	REPSOL (SP)	RWE (DE)	SIEMENS (DE)
NTNU (NO)	ENI (IT)	PPC (GR)	BASF (DE)
BGS (UK)	ROHOEL (AT)	EON-UK (UK)	GVS (IT)
BGR (DE)		SUEZ-ELECTRABEL (BE)	
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: 2,7 M€

Duration: 4 years

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

Why developing post-combustion capture ?

- Post-combustion capture is important because of large existing stock of power plants and boilers but also for new plants, as the cheapest will be conventional ones based on direct combustion of fuel
- Large-scale demos have been announced/scheduled:
  - RWE in Germany (coal-fired steam power station)
  - Halten (Shell-Statoil) in Norway (gas-fired power station in 2012, with EOR)
  - American Electric Power in USA (coal-fired steam power station)

Mountaineer Plant - New Haven, WV

Northeastern Plant - Oologah, OK

CASTOR pilot plant

Capacity: 1 t CO2/h

5000 Nm3/h flue gas (coal combustion)

In operation since early 2006

January - March 2006: MEA-testing for 1000 hrs
September - November 2006: 2nd MEA-testing for 1000 hrs
March - June 2007: CASTOR1-testing
September - December 2007: CASTOR2-testing

Base Case (MEA) overview with and without capture

Item	Bituminous coal		GTCC		Lignite DE	
	without Capture	Capture Integrated	without capture	Capture Integrated	without capture	Capture Integrated
Gross Capacity (MW, LHV)	600	600	393	393	1000	1000
Net power output (MW)	575	442	385	325	920	646
Thermal efficiency, % (LHV)	**45**	**34.0**	**56.5**	**47.6**	**49.2**	**34.5**
CO_2 emission (kg/MWh)	772	103	366	42	812	116

CASTOR post-combustion: Status and achievements today

- CASTOR results have been used to determine power plant performances with CO_2 capture for Technology Platform ZEP Strategic Research Agenda
- Anticipated final result:
  - Novel solvents with 25% reduction in E-requirement (4 → 3 GJ/ton CO_2)
  - Process concepts leading to another 25% reduction in E-requirement (3 → 2 GJ/ton CO_2)
- European industry interest in post-combustion capture has exponentially grown:
  - Power companies have been learning quickly and are rapidly progressing towards the status of an informed buyer
  - Solvent supplier is able to compete in future CO_2 markets

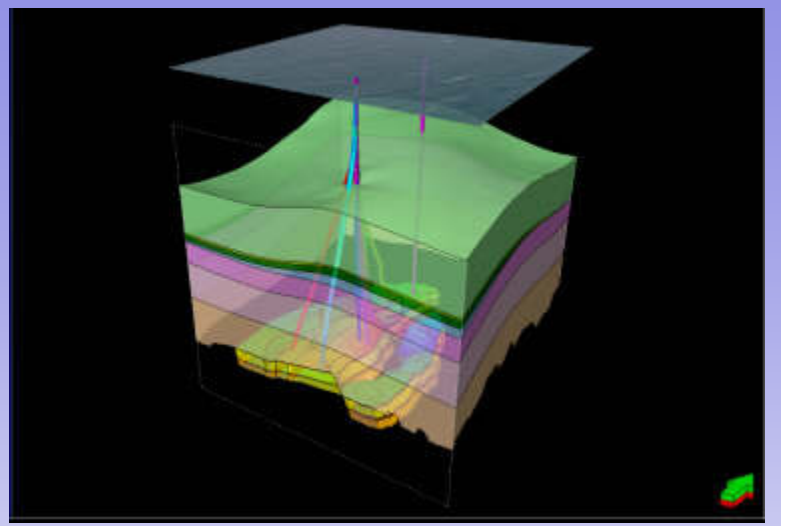
CO_2 Geological Storage

No capture without 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 management

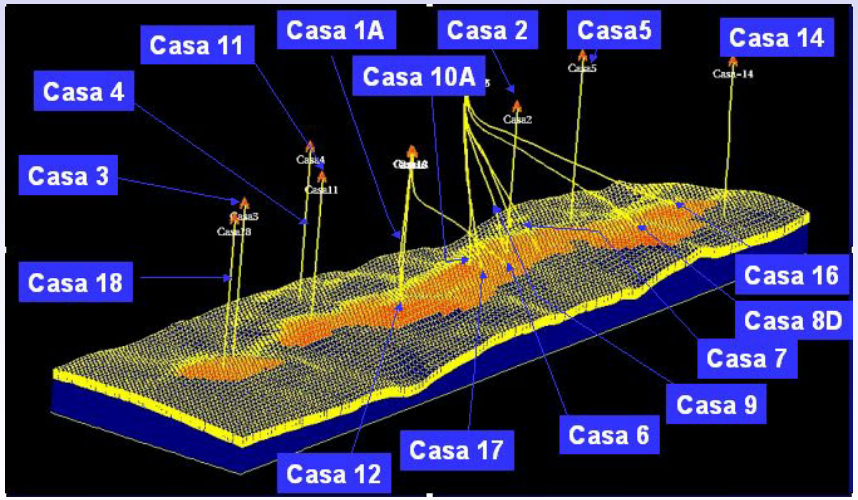
CASTOR workflow for site studies

- Data gathering, geomodel building
- Analysis of fluid flow properties
- Reservoir simulation
- Geochemical, geomechanical experiments and simulations
- Well integrity analysis
- Long term modelling and simulation
- Monitoring of stored (and escaping!) CO_2
- Integrated risk assessment analysis



K12-B geological model

Rock samples from Atzbach



Casablanca reservoir model

Casablanca oilfield (Repsol, Spain)

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

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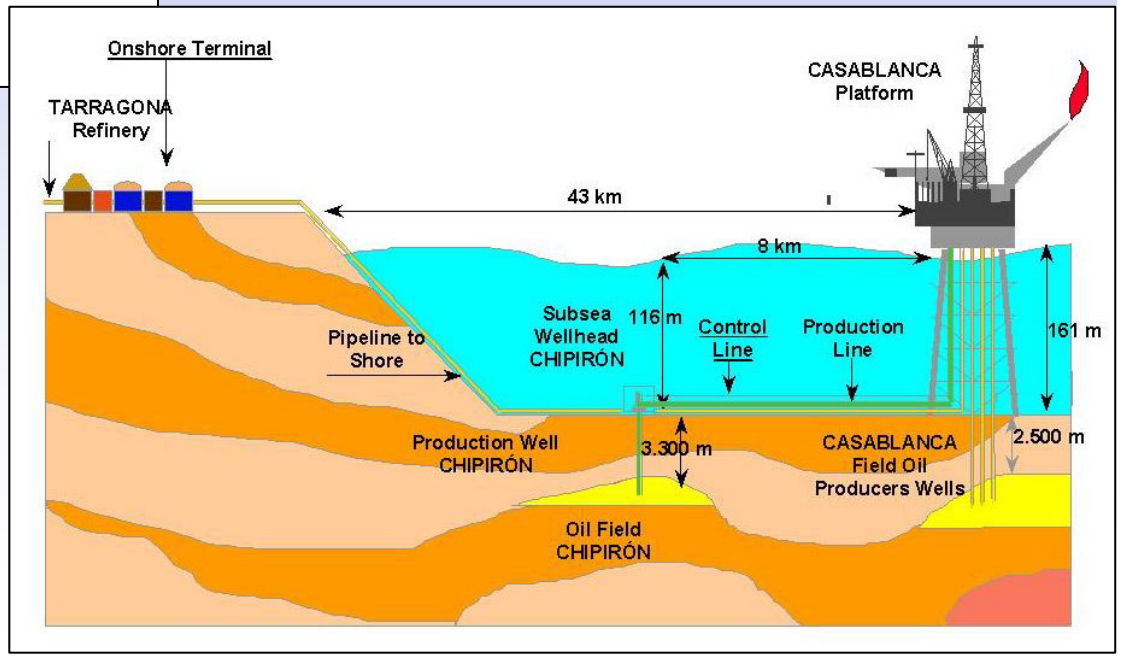
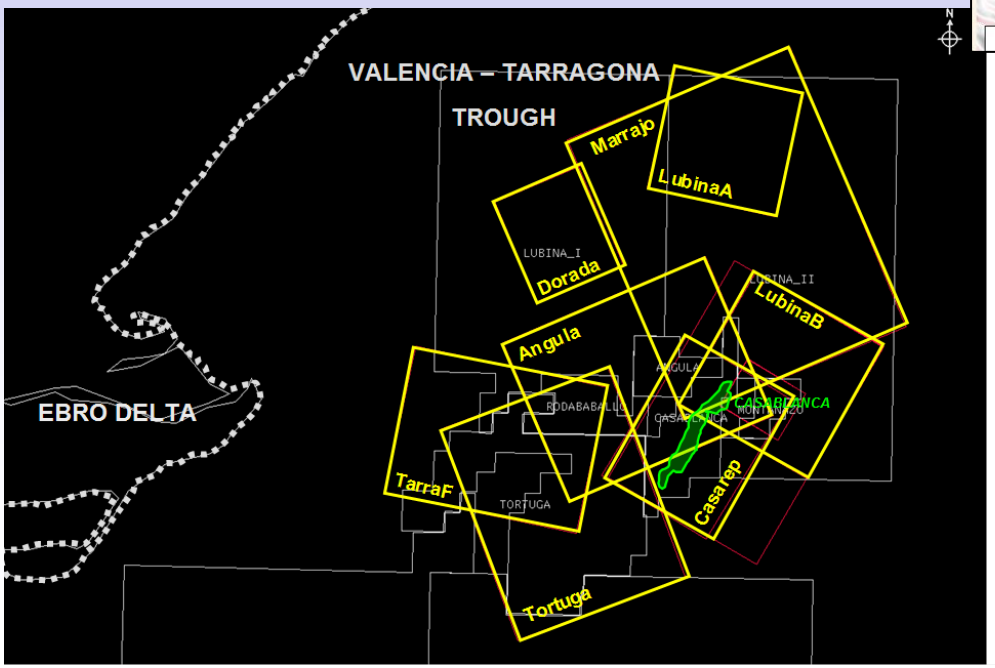
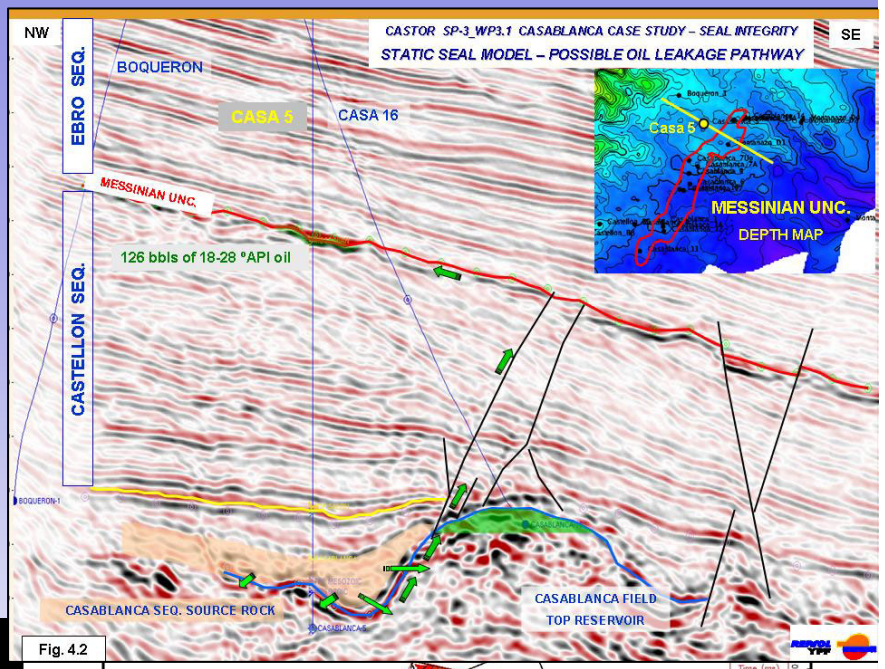


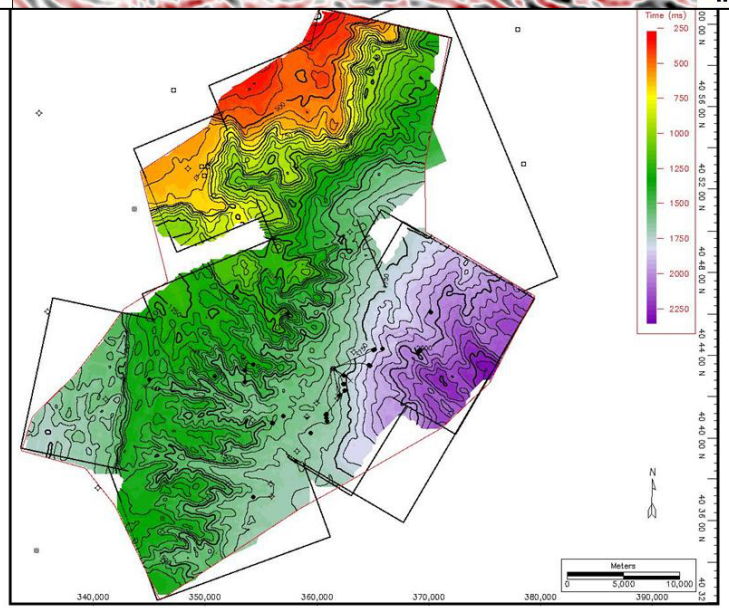
Casablanca oilfield (Repsol, Spain)

- Highlights:
  Regional seal characterization

3D datasets used

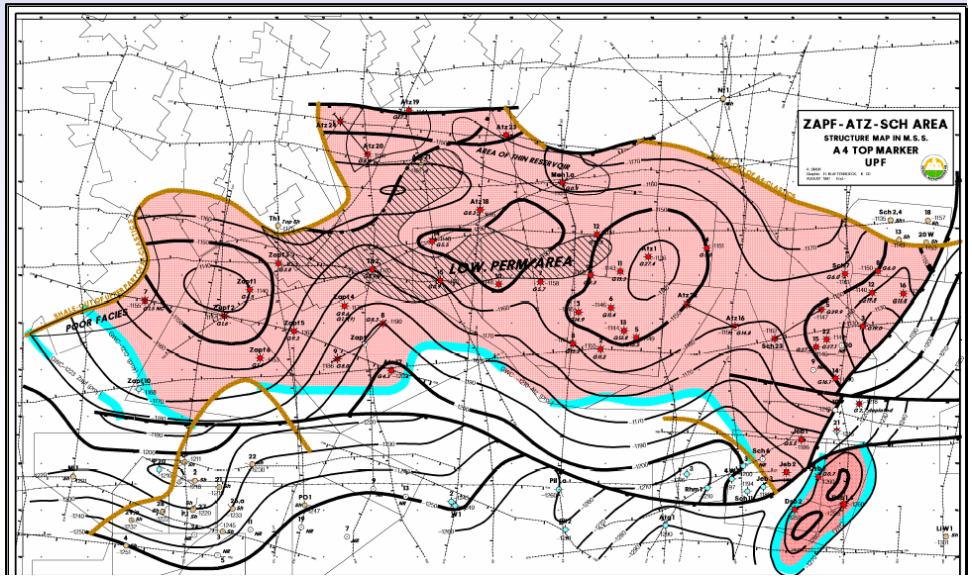






Atzbach-Schwanenstadt Gas Field (Rohoel, Austria)

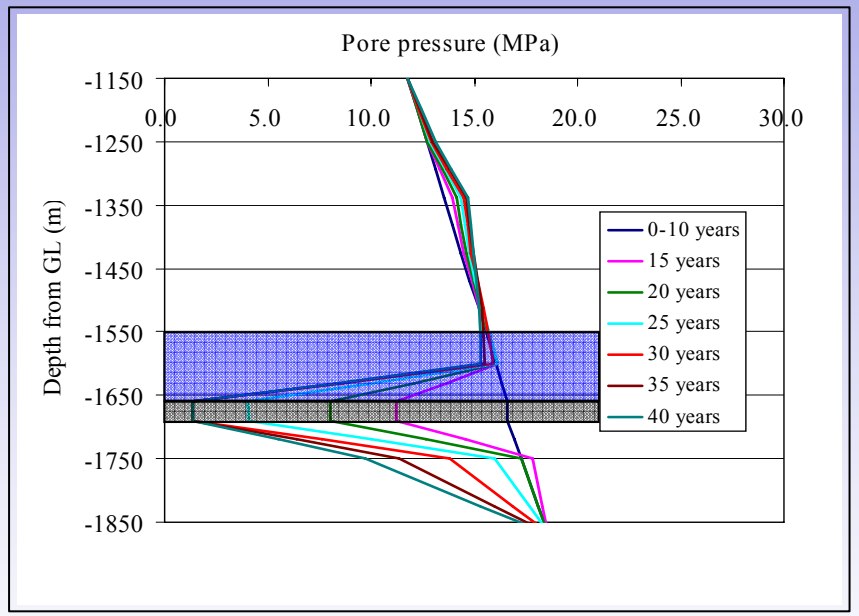
- **Sandstone gasfield, onshore**
- **Depth: 1600 m**
- **Possible injection of 200,000 t CO_2/year**
- **Opportunity for EGR**

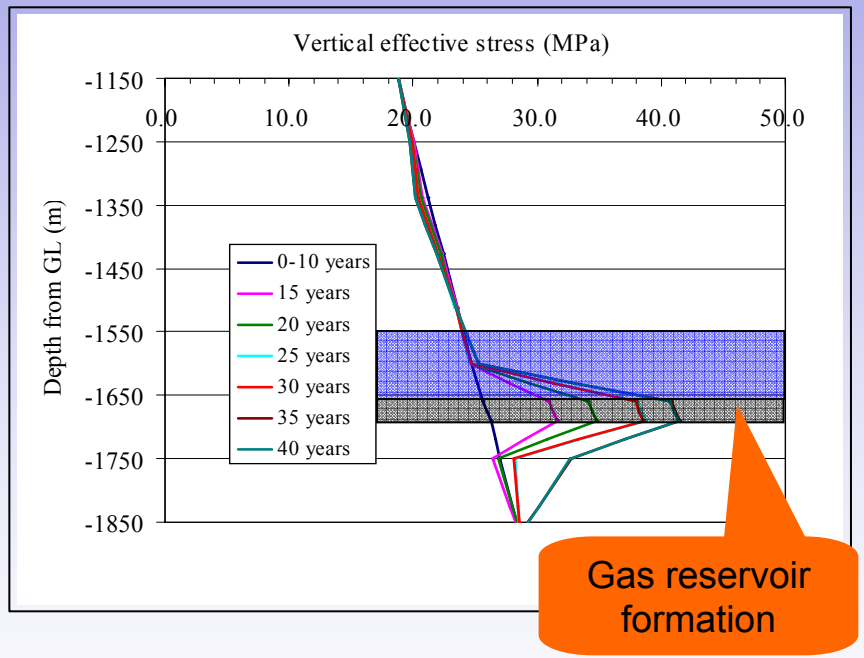


Atzbach-Schwanenstadt Gas Field (Rohoel, Austria)

Highlights: Geomechanical modelling, 3D

1/8 model; 5km x 3 km x 2450 m

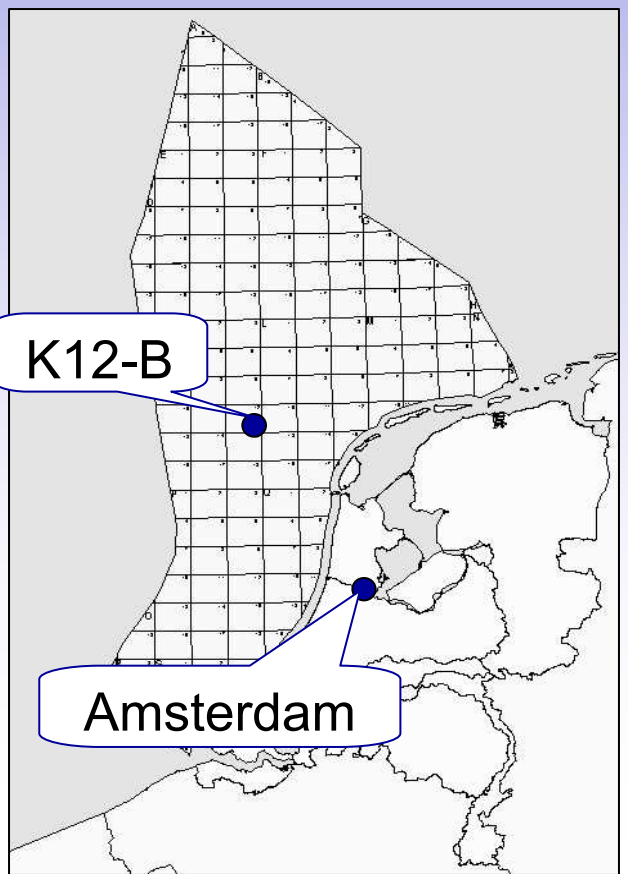




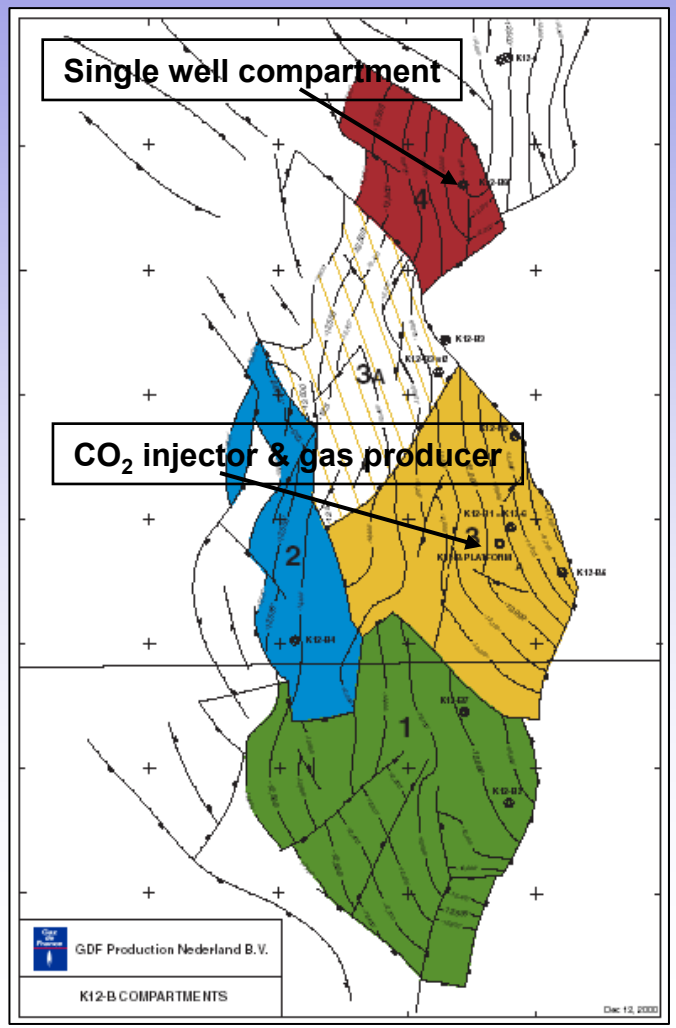
- Pore pressure reduction confined to around the gas reservoir formation
- Stress changes confined to around the gas reservoir formation

K12-B 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 2008 ?, 8 Mt total**

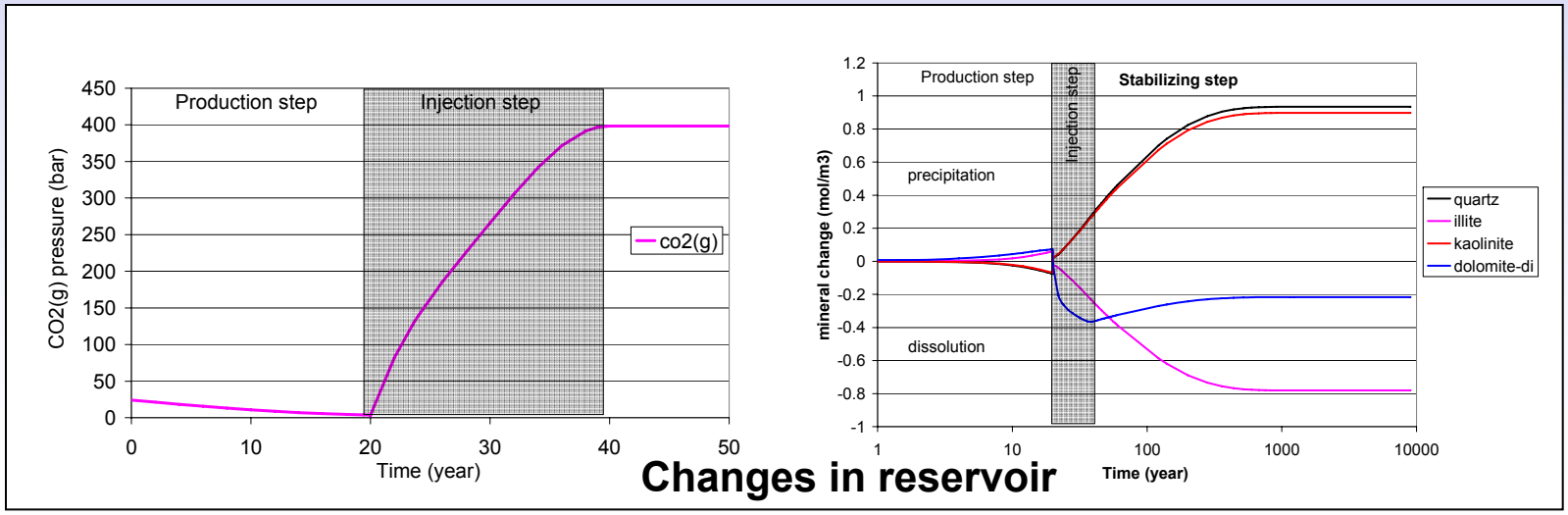


Gaz de France



K12B Gas Field (Gaz de France, The Netherlands)

- **Highlights: Geochemical modelling**
  - Batch modelling of CO_2 injection
    - For reservoir sandstone rock and for two cap-rocks
    - Reservoir: low reactivity, already equilibrated with CO_2
    - Cap-rocks: larger reactivity than reservoir, but still low. Limited mineral trapping, only slightly reduced porosity (< 1.5%).



Changes in reservoir

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)

  ⇒Solvent & process validated with lower energy requirement (3 GJ/t CO_2)
  - Building confidence in CO_2 geological storage by adding 4 more cases to the portfolio of existing sites:
    - Start CO_2 injection on Snohvit in Oct. 2007
  - CASTOR Follow-up:
    - CESAR "CO_2 Enhanced Separation And Recovery"
    - AQUA CO2 "Qualification of deep saline aquifers for CO_2 storage"