

Fourth Annual Conference on Carbon Capture & Sequestration

*Developing Potential Paths Forward Based on the
Knowledge, Science and Experience to Date*

Geologic Sequestration

***"CASTOR" - CO₂ from Capture to Storage - An innovative
European Integrated Project***

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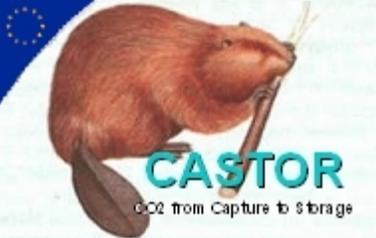
Tore A. Torp (Statoil), Paul Feron (TNO), Peter Zweigel, Erik Lindeberg (SINTEF Petr. Res.)

May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

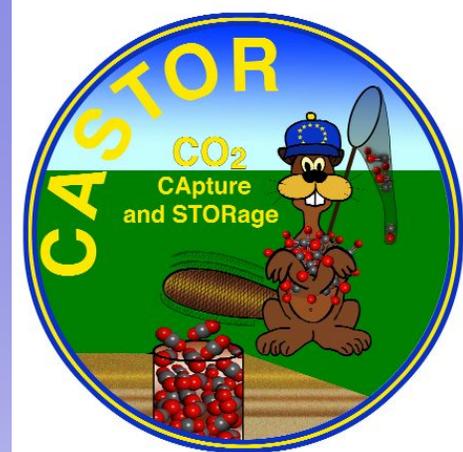


Presentation outline

- Castor at a glance
- Few comments on capture
- Work performed on CO₂ geological storage
- The way forward



CASTOR at a glance



- Objectives:
 - Reduce the cost of CO₂ 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 CO₂ / hour)
 - Detailed studies of future storage projects
- Funded by the European Commission under the 6th Framework Programme

CASTOR at a Glance (2)

R&D

IFP (FR)
TNO (NL)
SINTEF (NO)
NTNU (NO)
BGS (UK)
BGR (DE)
BRGM (FR)
GEUS (DK)
IMPERIAL (UK)
OGS (IT)
TWENTE U. (NL)
STUTTGARTT U. (DE)

Oil & Gas

STATOIL (NO)
GDF (FR)
REPSOL (SP)
ENITecnologie (IT)
ROHOEL (AT)

Power Companies

VATTENFALL (SE)
ELSAM (DK)
ENERGI E2 (DK)
RWE (DE)
PPC (GR)
POWERGEN (UK)

Manufacturers

ALSTOM POWER (FR)
MITSUI BABCOCK (UK)
SIEMENS (DE)
BASF (DE)
GVS (IT)

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

Sub-project "Post-combustion capture"

- Lead by TNO (The Netherlands)
- Objectives
 - Development of absorption liquids, with a thermal energy consumption of 2.0 GJ/tonne CO₂ at 90% recovery rates
 - Resulting costs per tonne CO₂ avoided not higher than 20 to 30 €/tonne CO₂, 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 CO₂-capture technology

- Absorption technology is leading option but:
 - Power cost increases >50%
 - Generation efficiency decreases by 15 – 25%
- Absorption process break-throughs 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

European post-combustion test facility

Esbjergværket



Capacity: 1 t CO₂ / h

5000 Nm³/h fluegas
(coal combustion)

In operation early 2006

The greatest pilot worldwide

SP3 "CO₂ geological storage"

- Lead by SINTEF Petroleum Research (Norway)
- 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

SP3 "CO₂ 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

Major expected results

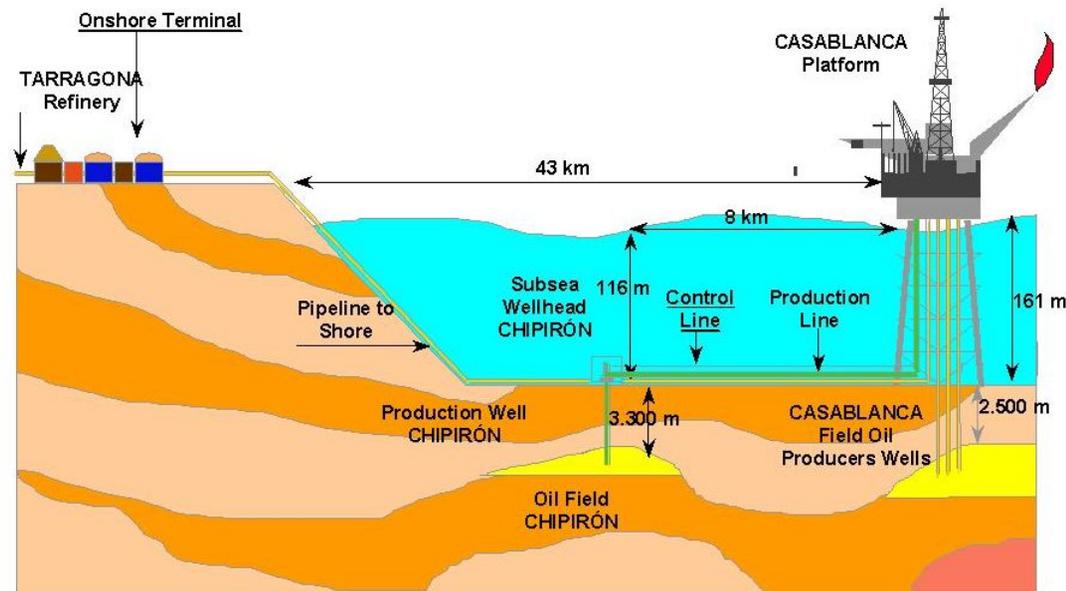
No capture without storage!

- The main issue in storage is public acceptance
- Public acceptance requires proven or highly likely safety
- No generally accepted methodology to predict storage performance (safety) exist
- Four additional cases will – in case of successful studies & performance – increase public credit for storage technology

Casablanca oilfield (Repsol, Spain)



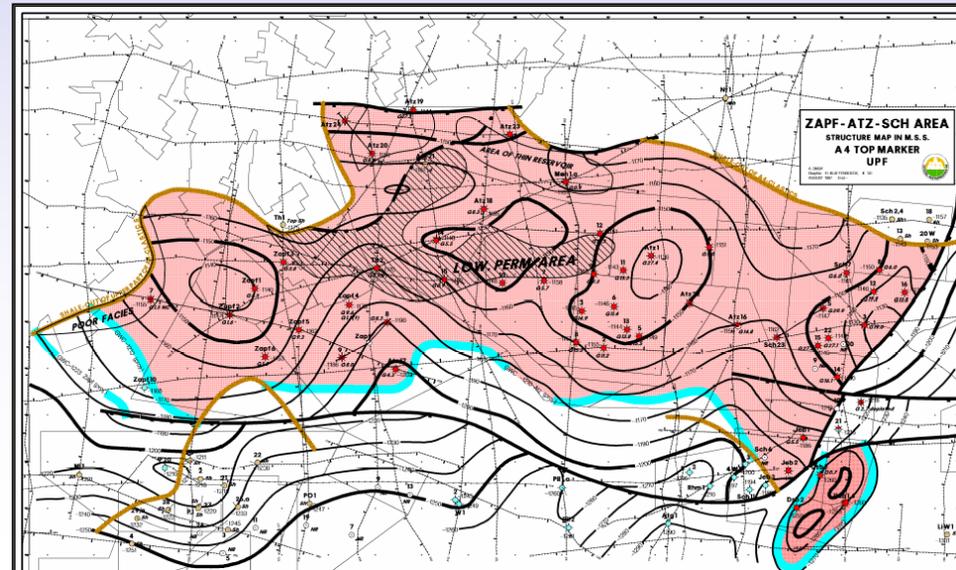
- Depleted oil-field in carbonates
- Depth: 2500 m
- Injection of 0,5 Mt CO₂ / year from the Tarragona Refinery



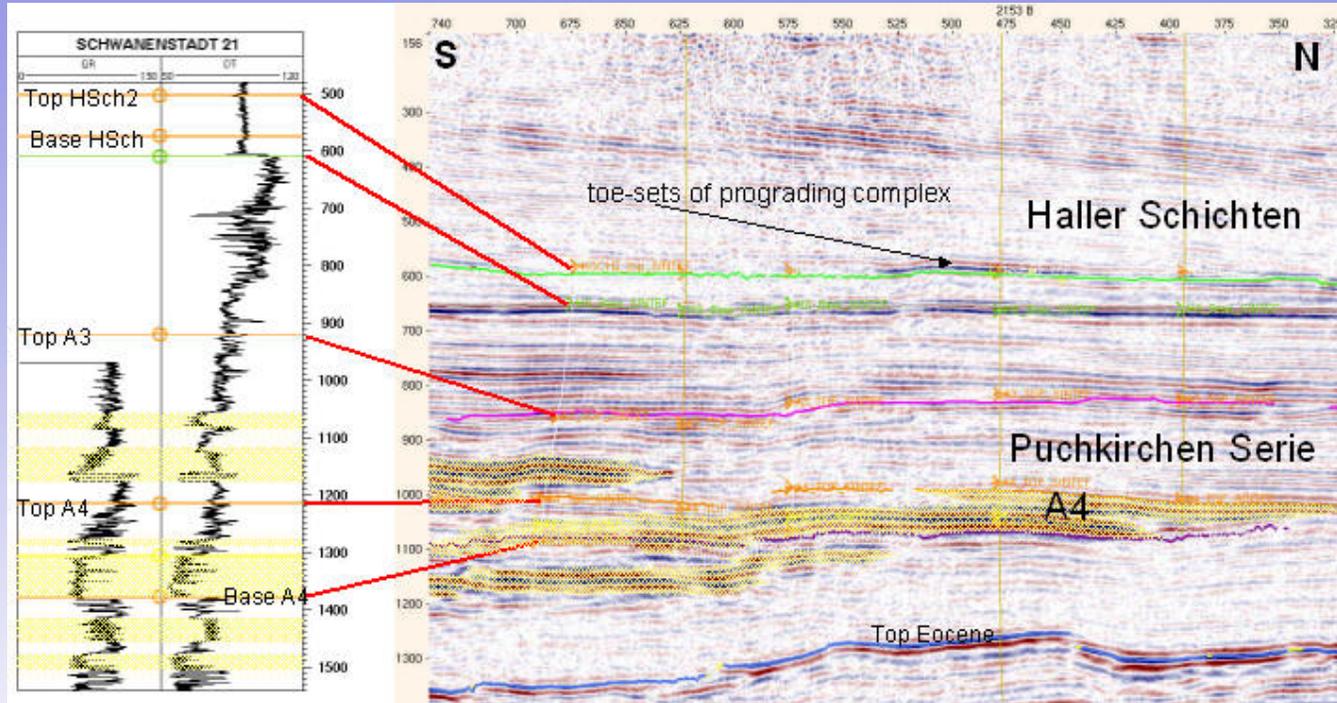
Atzbach-Schwanenstadt Gas Field (Rohoel, Austria)



- Sandstone gasfield, onshore
- Depth: 1600 m
- Possible injection of 200,000 t CO₂/year
- Opportunity for EGR



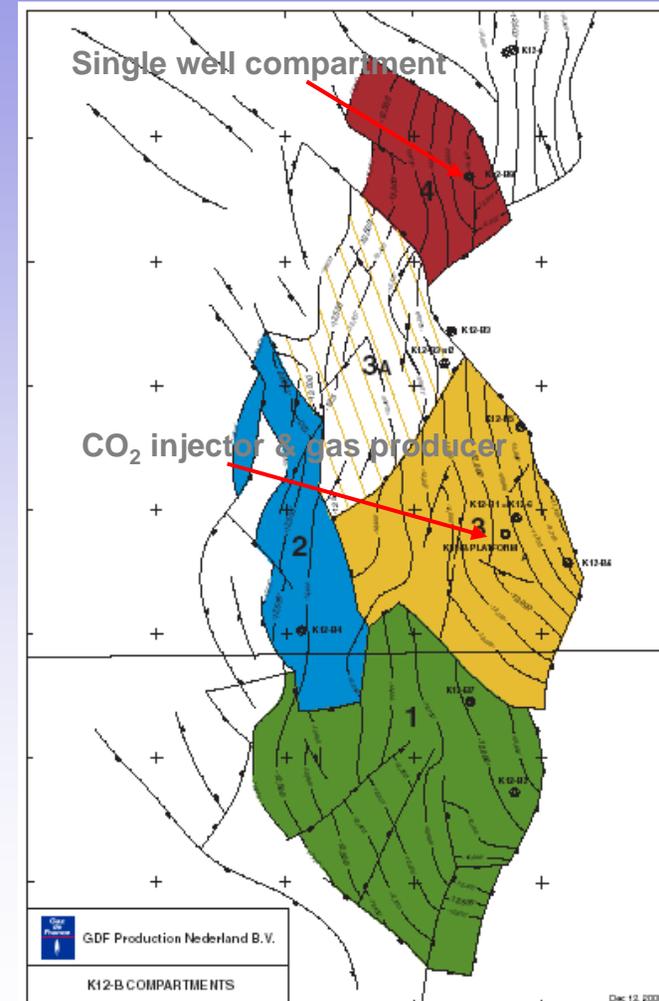
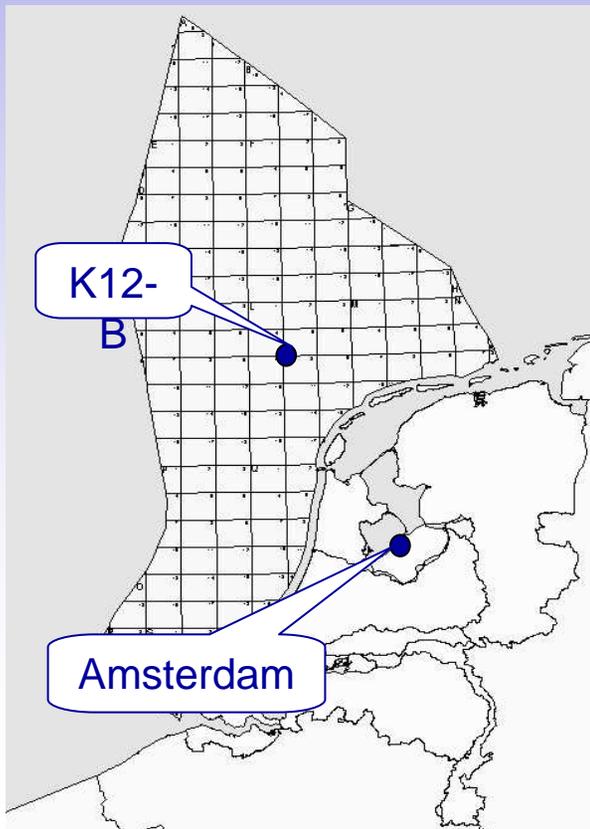
Atzbach-Schwandenstadt Gas Field (Rohoel, Austria)



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)

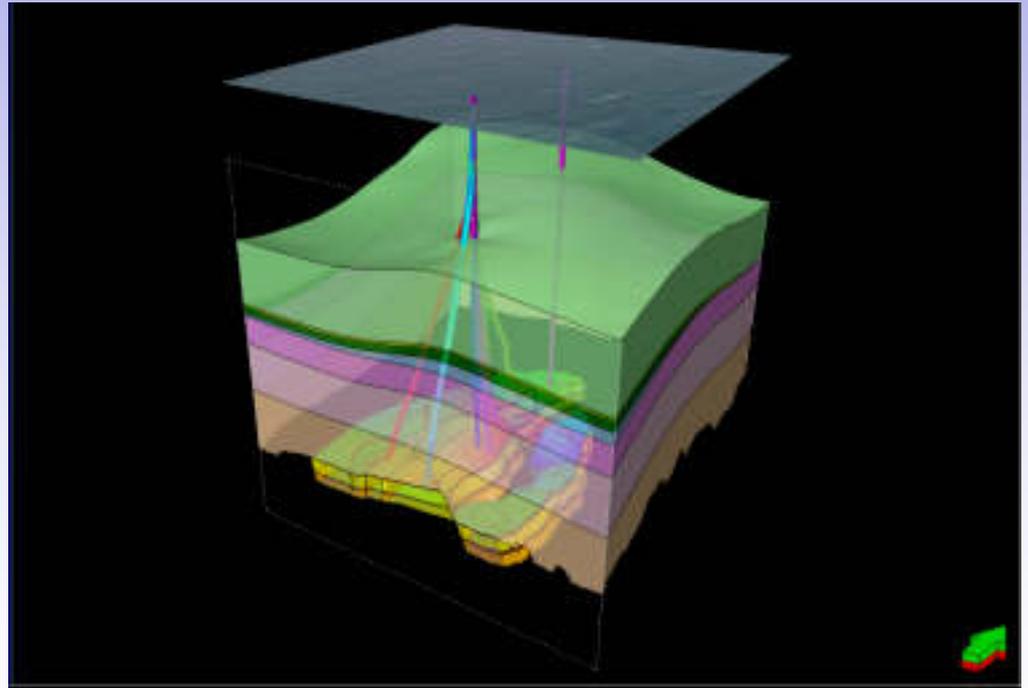
Focus: general storage site evaluation; long-term safety, monitoring (seismics).

Improved geological model

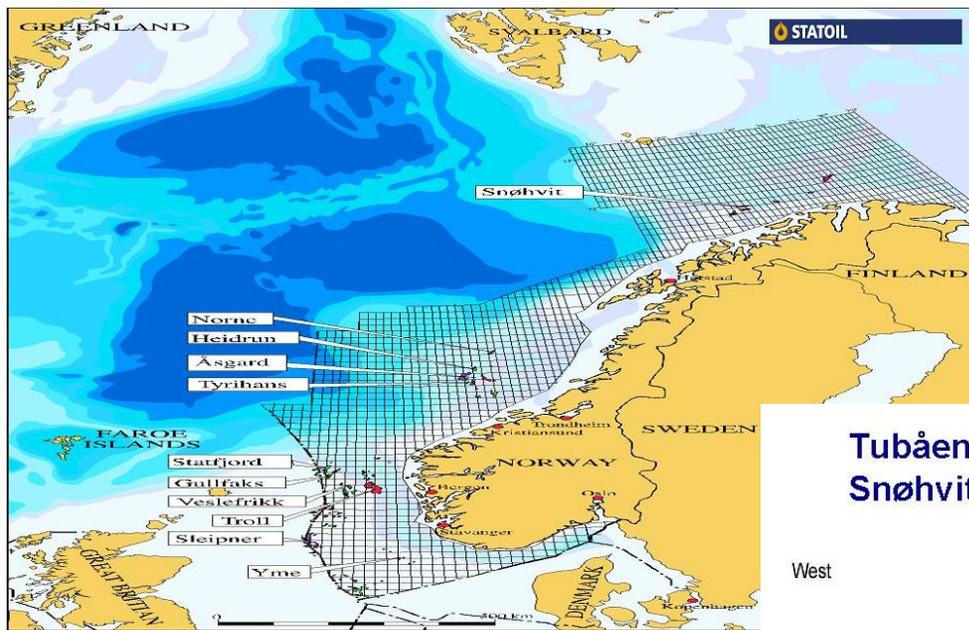
- Facies model was established
- 3D seismic interpretation for the K12B field
- Petrophysical log analysis on all K12B wells

Experimental work

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



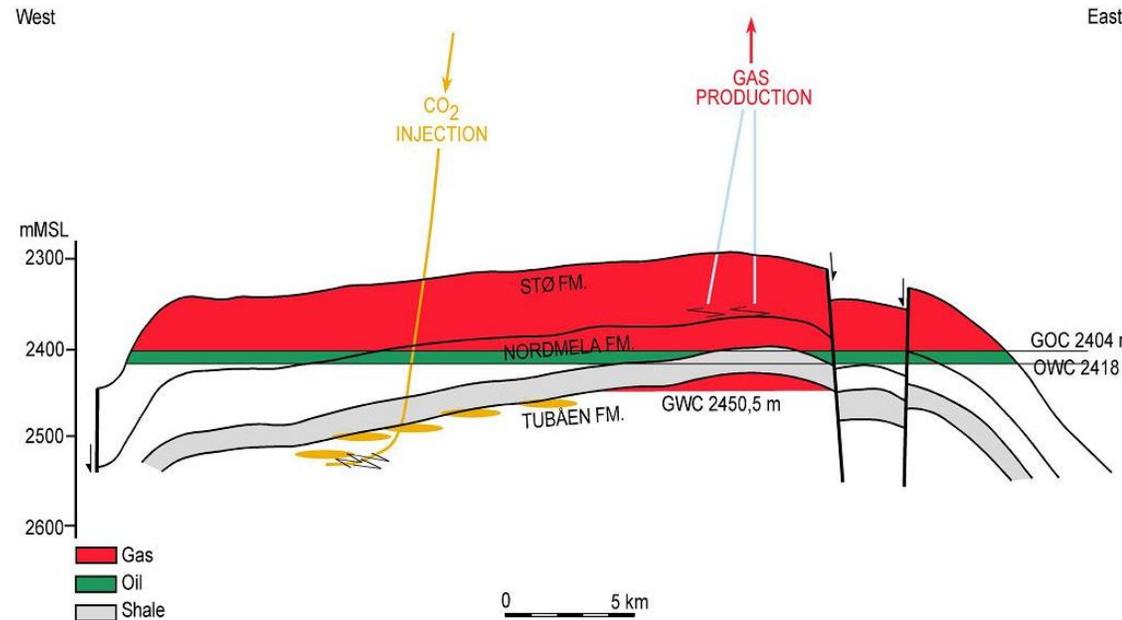
Snohvit Aquifer (Statoil, Norway)



- Sandstone aquifer, offshore
- Depth: 2500 m
- 0.75 Mt CO₂ per year; Start in Oct 2006 and last for 20 + years
- CO₂ source is removal from natural gas before cooling to LNG; limit 50 ppmvol.

Tubåen Formation storing CO₂ under the Snohvit Field

STATOIL

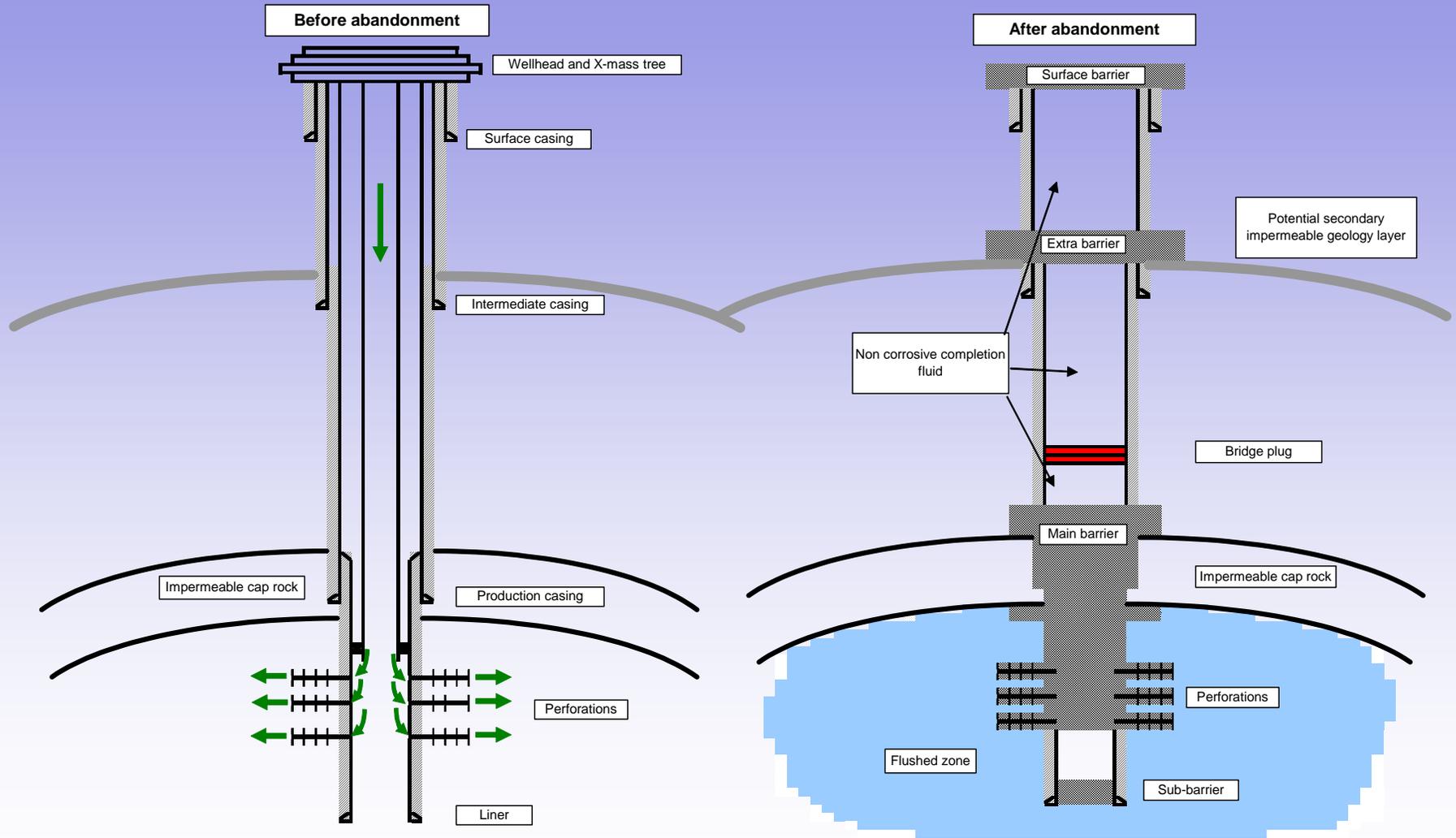


**Focus: Well integrity,
Injectivity, Monitoring**

Preventive & corrective actions

- Review report on existing preventive and corrective action technologies regarding prevention and/or halt of leakage at wellbores prepared.
- Work started on review report on existing preventive and corrective action technologies regarding leakage through rock and faults.

Preventive & corrective actions



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)
 - Building confidence in CO₂ geological storage by adding 4 more cases to the portfolio of existing sites:
 - K12B in the Netherlands: industrial scale in 2006
 - Start CO₂ injection on Snohvit in 2006