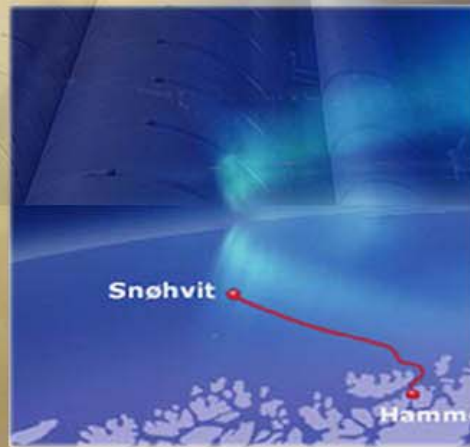
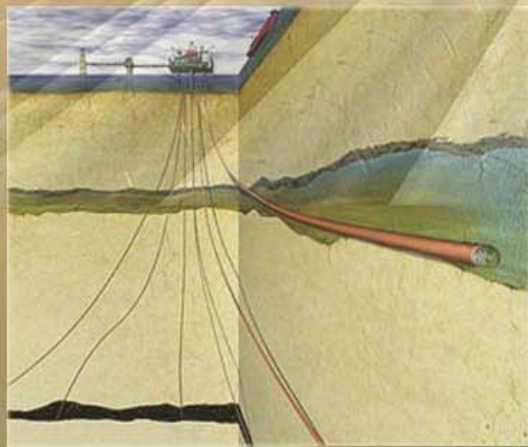




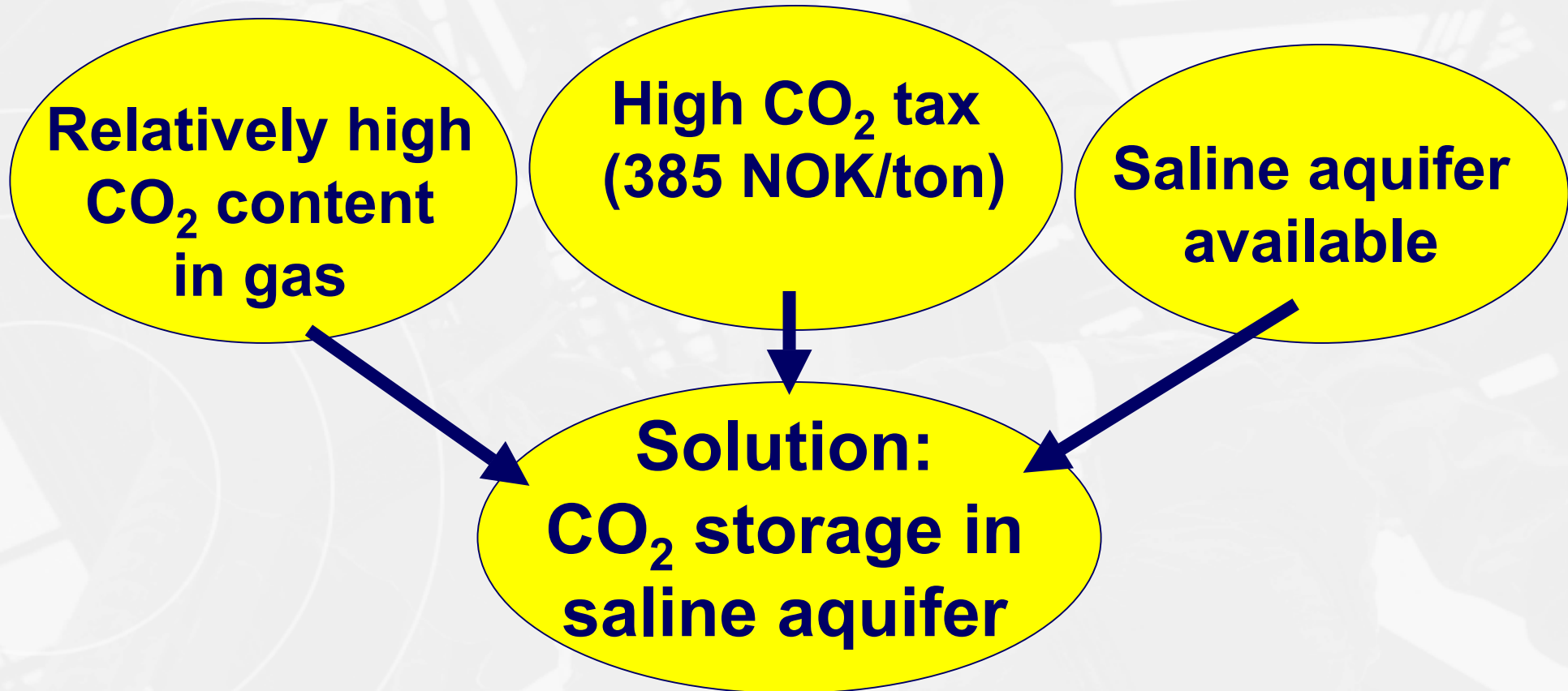
# The Sleipner & SACS experience

Bjørn Berger, Trude Sundset, Tore Torp

NorCap seminar, 14-15 October 2003, Trondheim

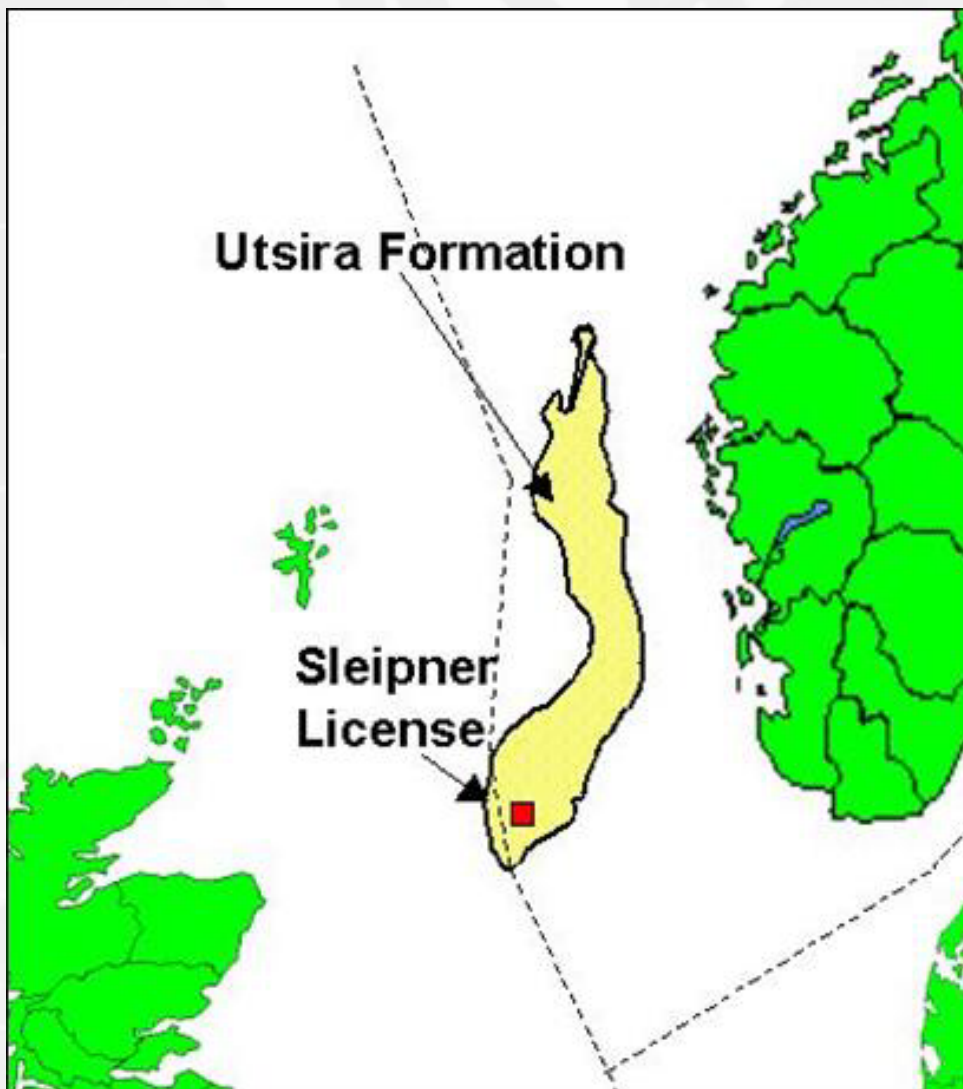


# The Sleipner decision: 1992



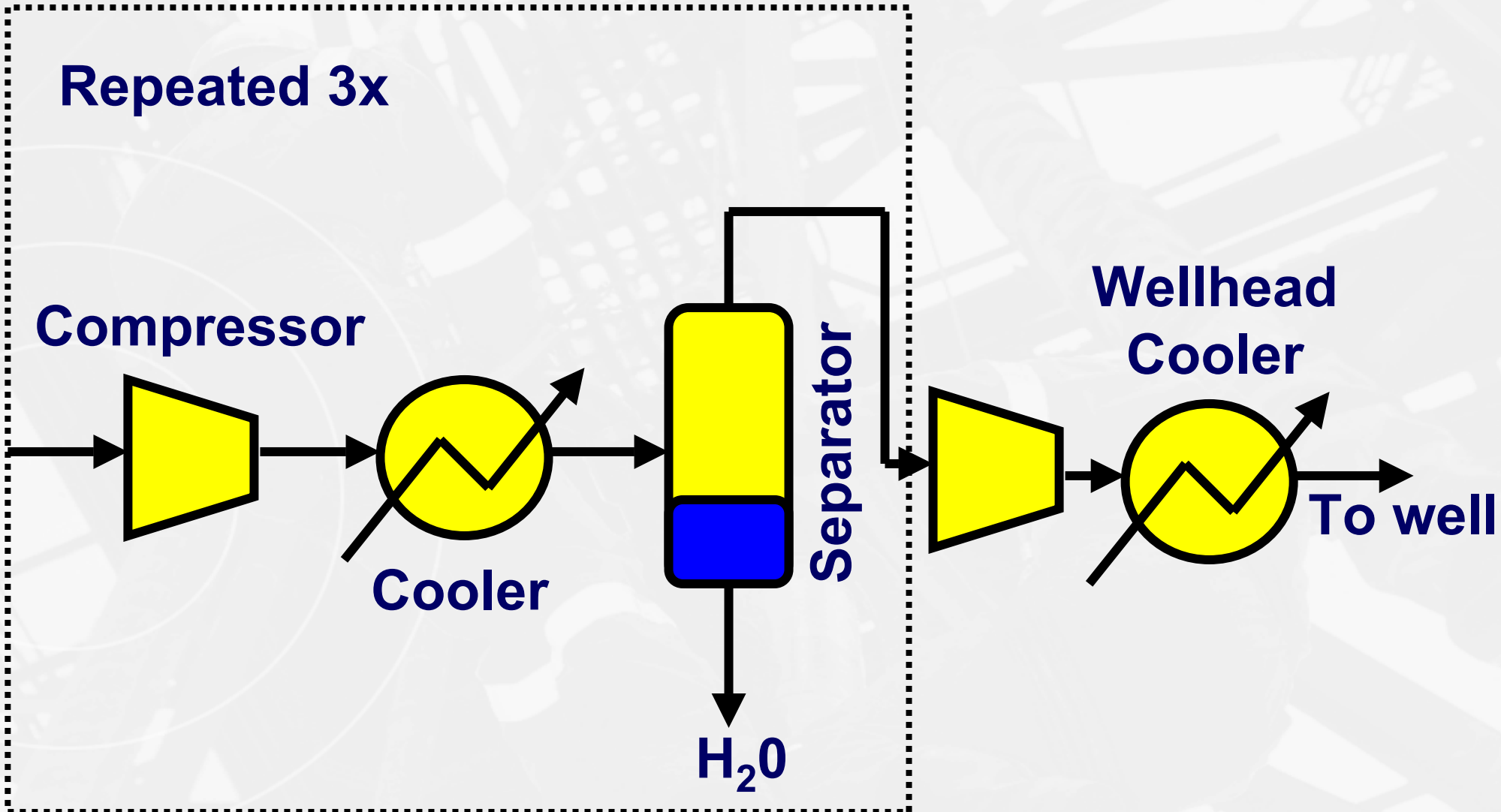
**Gas production and CO<sub>2</sub> injection started in 1996**

# The Utsira Formation



**The storage capacity is more than hundred times the annual European emissions**

# Process Flow Diagram of CO<sub>2</sub> Injection



# Main costs of CO<sub>2</sub> injection at Sleipner

- ✓ **No CO<sub>2</sub> capture investment for injection!**
- ✓ **Investments: 750 MNOK in 1996**
  - ✓ Drilling and completion of well
  - ✓ 4 Compressors
  - ✓ 4 Knock-out drums
  - ✓ 4 Coolers
- ✓ **Operational costs: 54 MNOK/year**
  - ✓ Fuel for compressors
  - ✓ CO<sub>2</sub> tax on compressor fuel exhaust
  - ✓ Maintenance

# Legal aspects

- ✓ **CO<sub>2</sub> injections at Sleipner and Snøhvit are legal**
- ✓ **Recent development: Dutch mining act in 2002**
- ✓ **OsPar meeting 13-14 Oct 2003:**
  - ✓ Orientation about CO<sub>2</sub> capture and storage
  - ✓ Discuss the necessity whether OsPar should be changed with respect to CO<sub>2</sub> storage
  - ✓ If yes, what?

**Dr.Ing. Tore A. Torp is present at the OsPar meeting**

# Saline Aquifer CO<sub>2</sub> Storage

**Statoil**  
**BP**  
**ExxonMobil**  
**TotalFinaElf**  
**NorskHydro**  
**Vattenfall**



**BGS**  
**BRGM**  
**GEUS**  
**IFP**  
**NITG-TNO**  
**SINTEF**



**IEA Greenhouse Gas R&D Programme**  
**Schlumberger Research**  
**NO, DK, NL, FR & UK Authorities**



**Research as basis for legal and public acceptance**

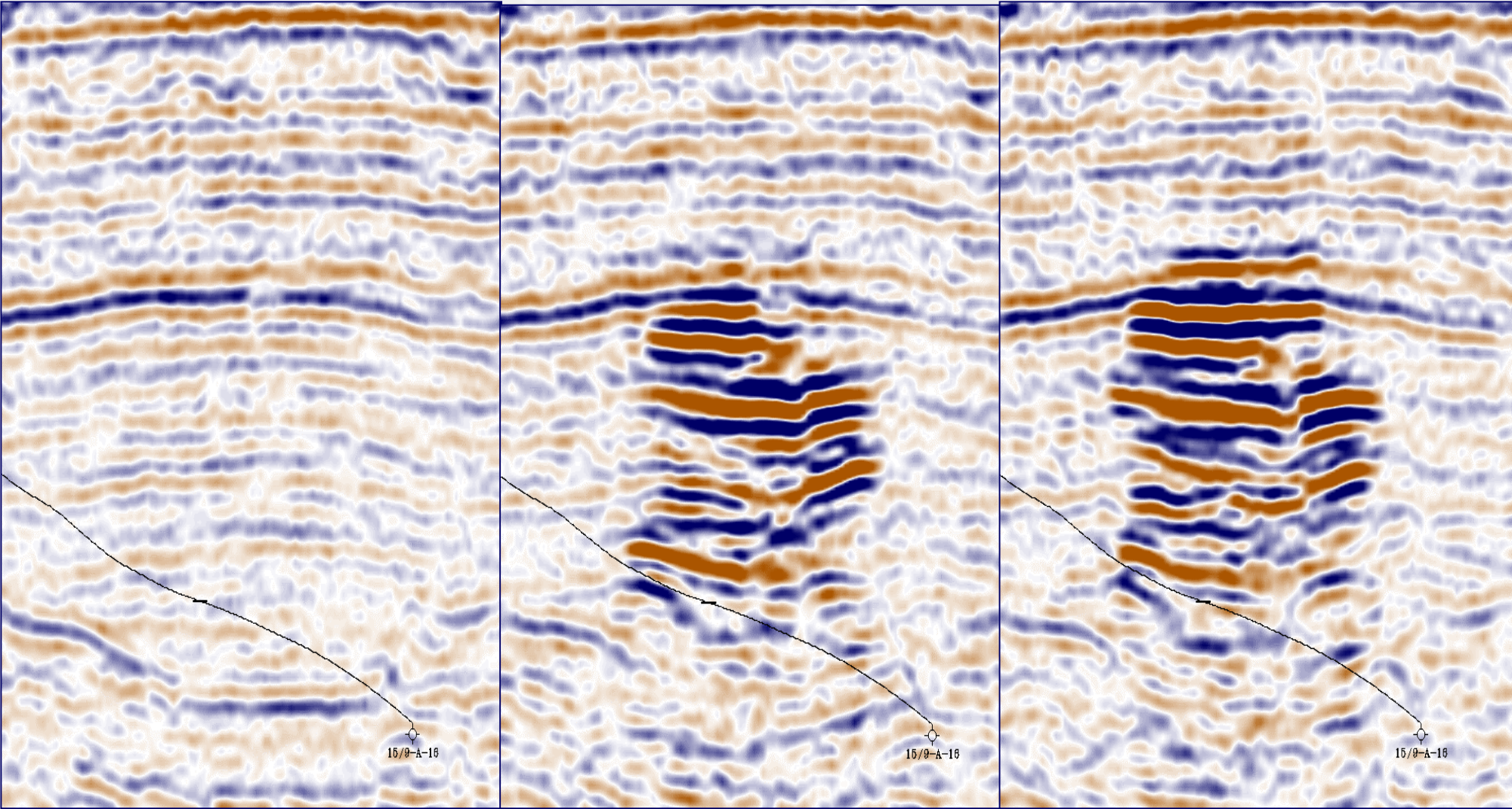
# 3D Seismic survey at Sleipner



1996

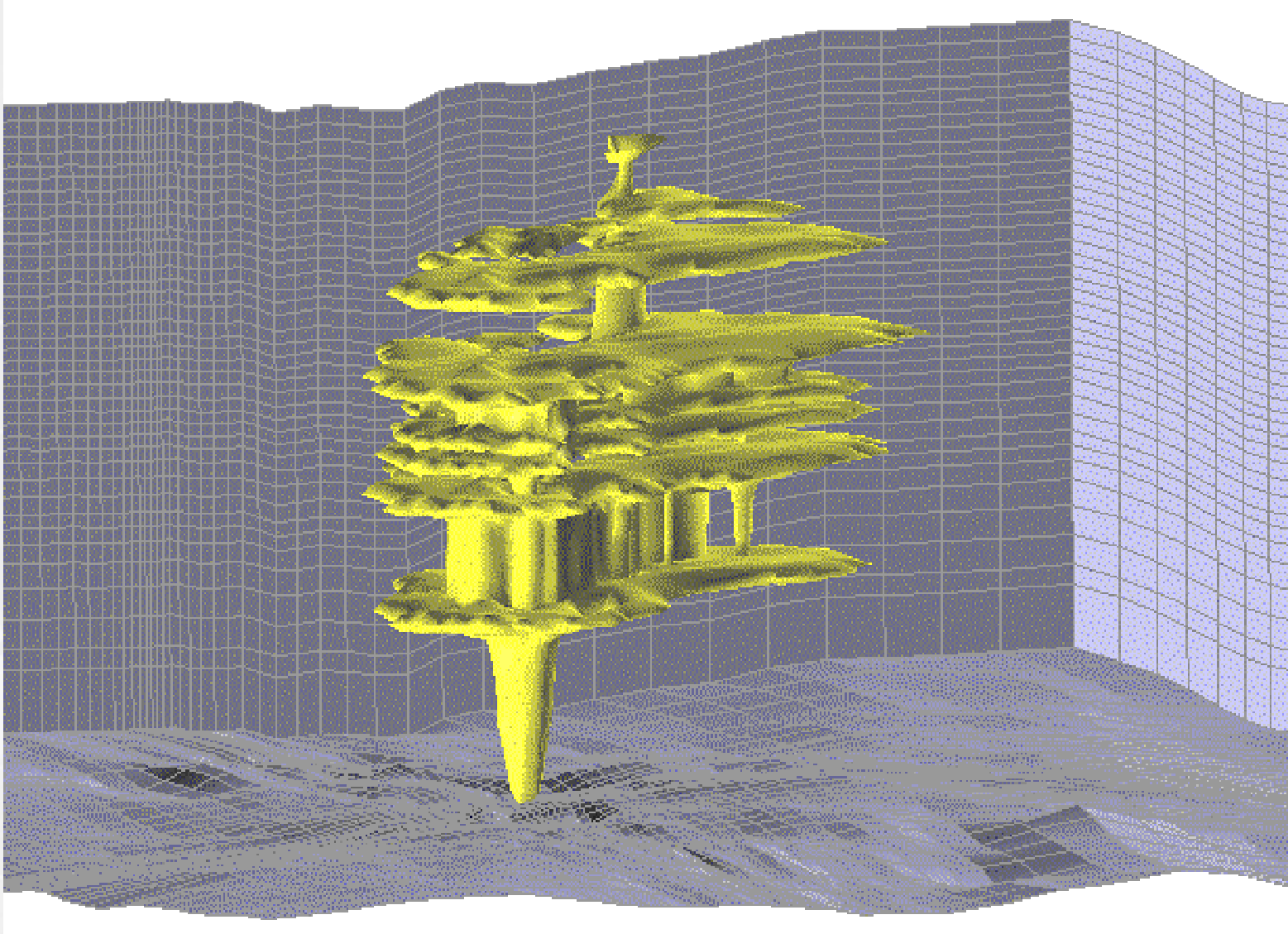
1999

2001



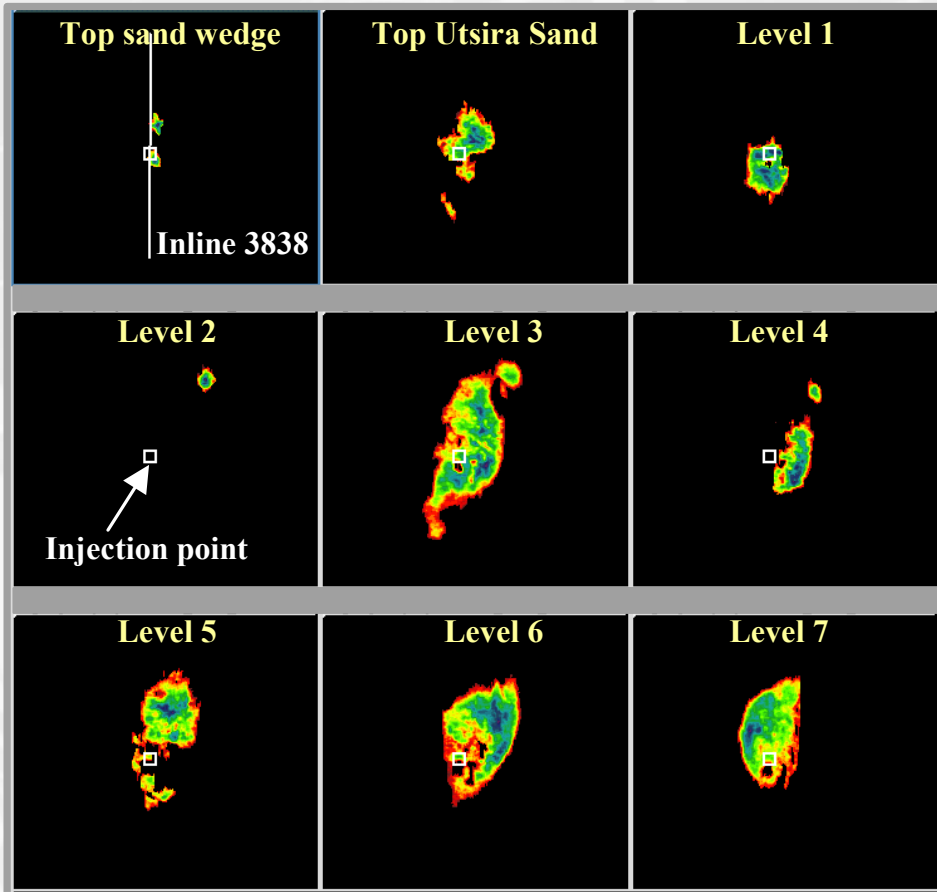


# Reservoir model of CO<sub>2</sub> after 3 years

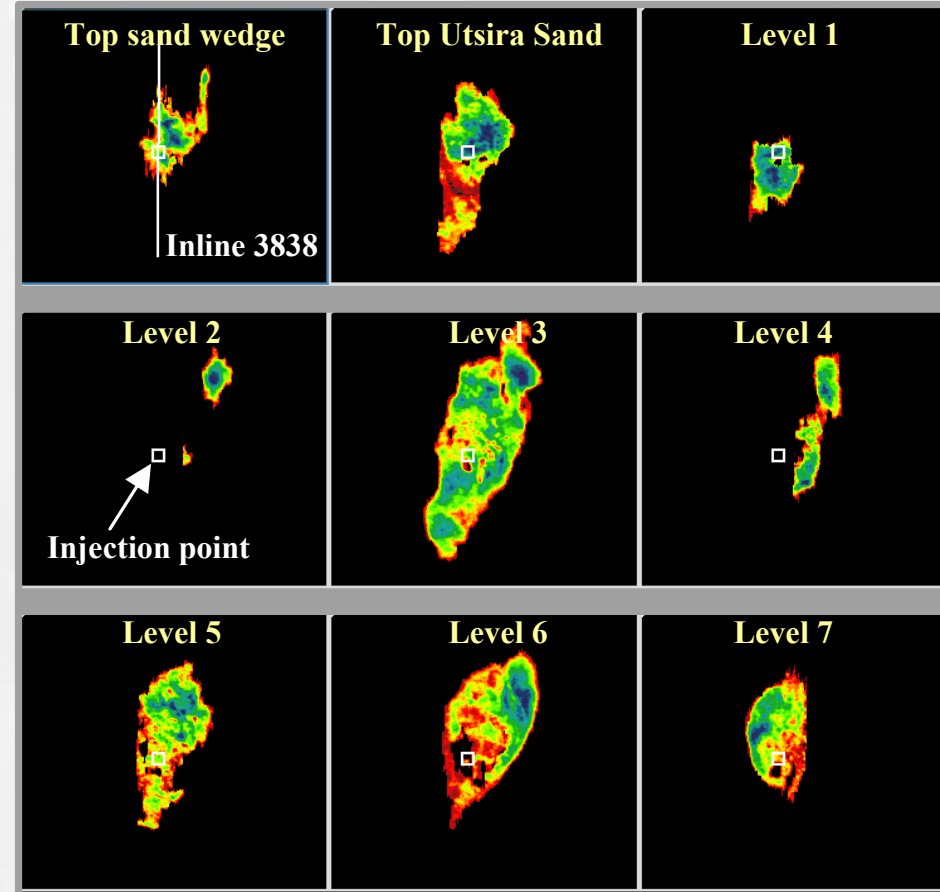


# CO<sub>2</sub> distribution in layers

CO<sub>2</sub> distribution in October 1999



CO<sub>2</sub> distribution in October 2001



2 km



# Geochemical analysis

Figure 1: Baseline geochemical data from the Utsira Formation available during the SACS project

## SLEIPNER

- 37°C, 8-11 MPa, 35-40 g/l
- 1 m core (well 15/9-A23)
- no fluid data (core porewater is highly contaminated by drilling mud)

## OSEBERG

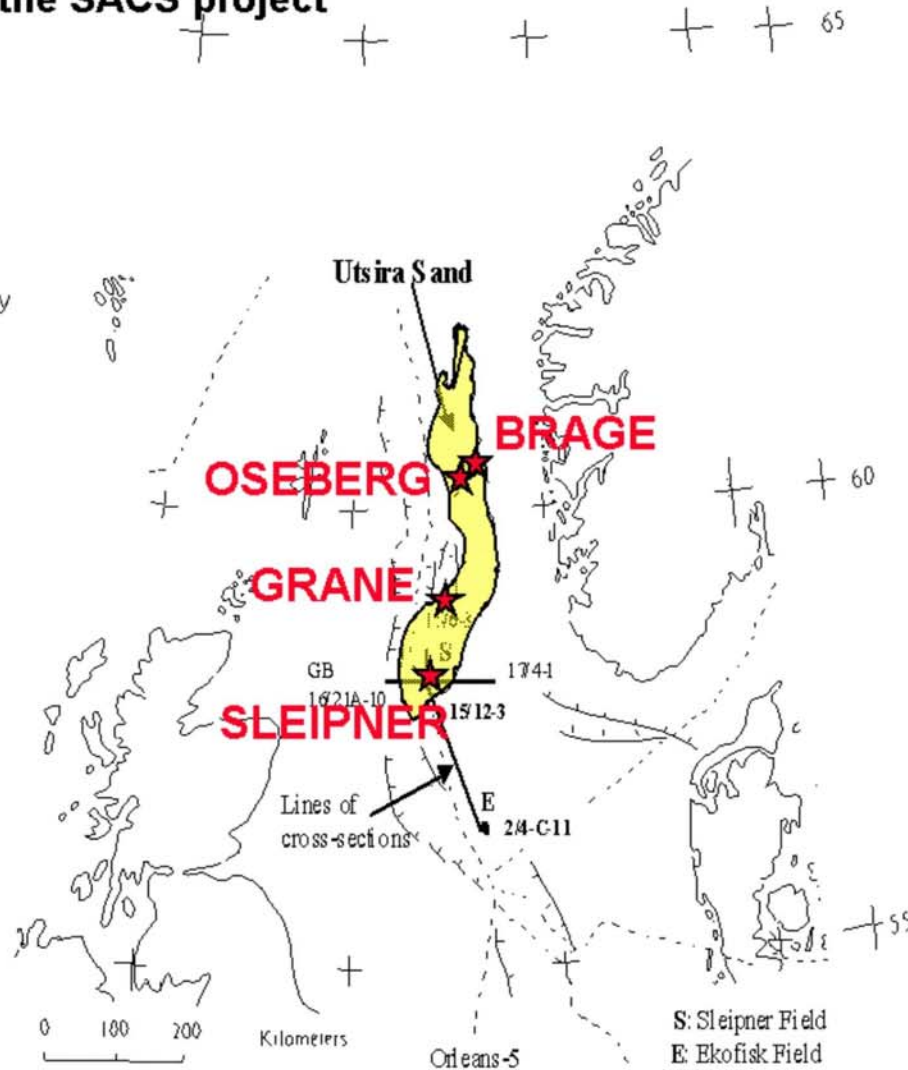
- 23°C, 7-9 MPa, 33-43 g/l
  - one surface fluid analysis
- 9 chemical elements: Na, K, Ca, Mg, Fe, Sr, Ba, C, Cl  
no Si, Al
- GWR and gas composition

## BRAGE

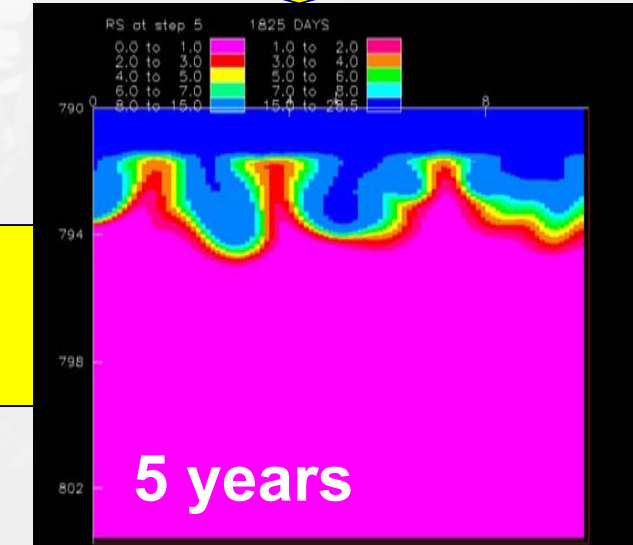
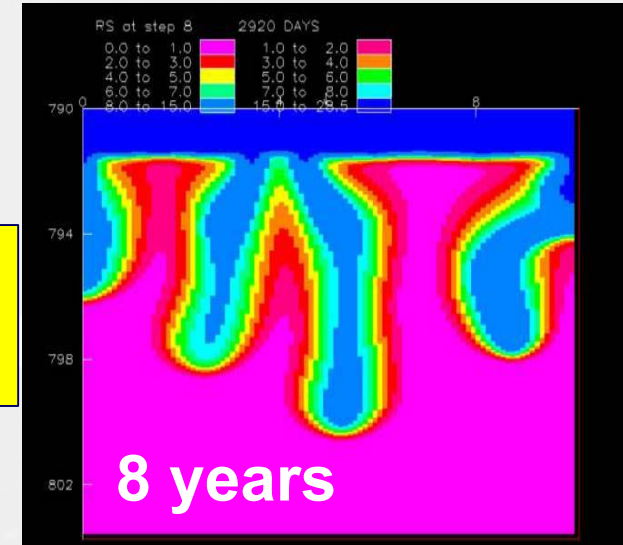
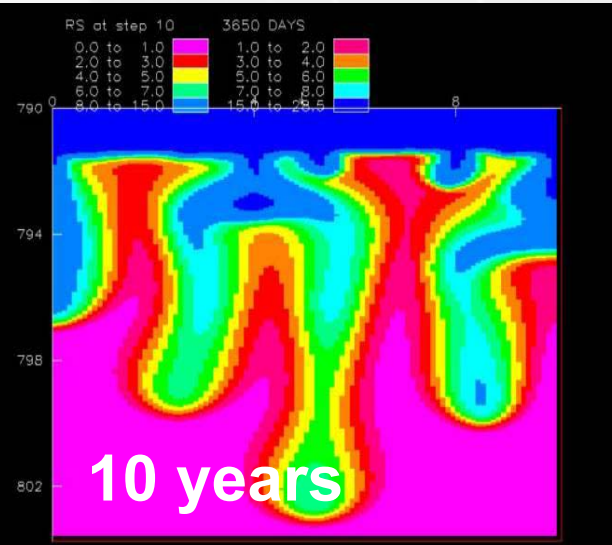
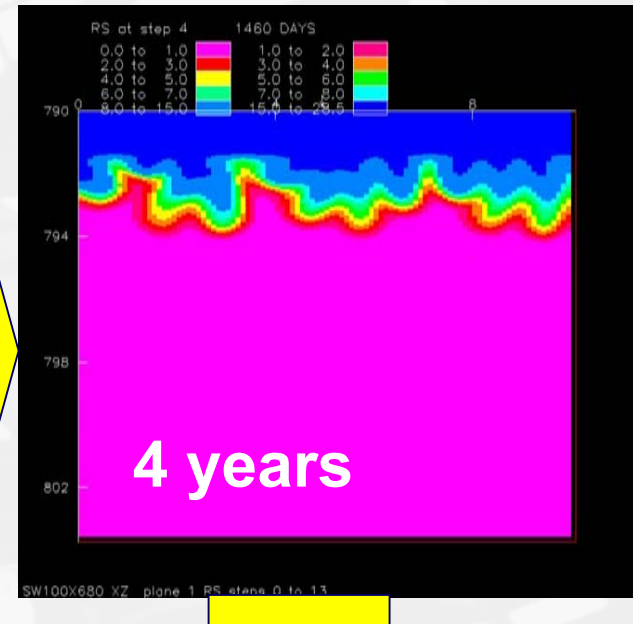
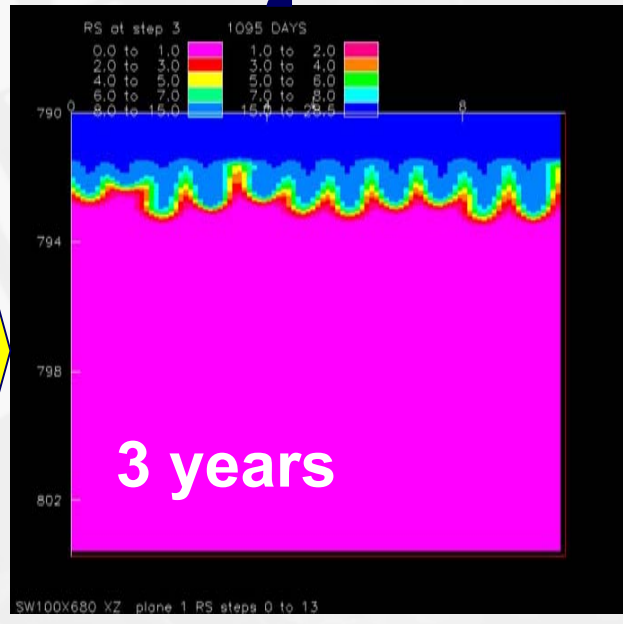
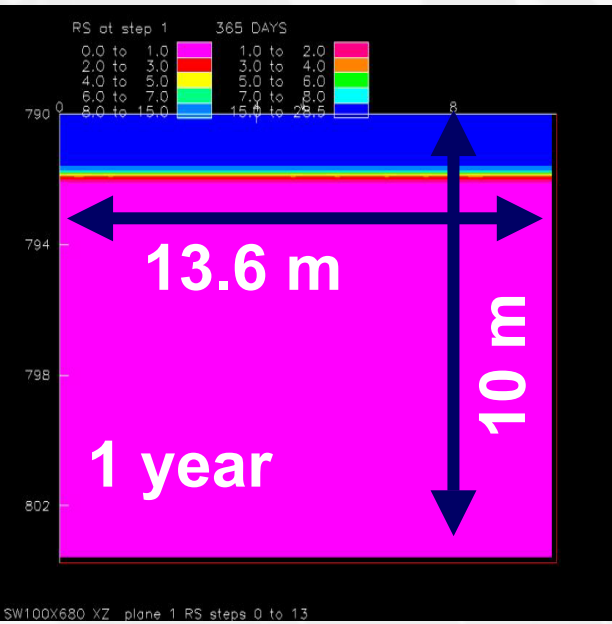
- ?
  - one surface water analysis
- 12 chemical elements: + Si, Li, Br Al < 0.1 mg/l
- no GWR and gas composition

## GRANE

- 33°C, 8-9 MPa, 35.5 g/l
- no fluid analysis



# Dissolution model of CO<sub>2</sub>/brine interface



## ✓ **SACS: What did we achieve?**

- ✓ 3D Seismic proven, Gravimetry tested
- ✓ Reservoir simulation tools partly proven
- ✓ Geology and Geochemistry of “Utsira” mapped
- ✓ Reason to expect the CO<sub>2</sub> stay for thousands of years
- ✓ **Best practise manual**

## ✓ **Next: CO2STORE 2003 – 2005:**

- ✓ Transfer Sleipner & SACS Experience:  
4 Field Cases DK, DE, UK and NO
- ✓ Long Term Behaviour: Geochemistry & Reservoir Simulation  
(incl. dissolution)
- ✓ Monitoring: 4<sup>th</sup> Seismic, 2<sup>nd</sup> Gravimetry

# Summary

- ✓ **CO<sub>2</sub> injection at Sleipner is well established and proven technology**
- ✓ **Offshore CO<sub>2</sub> tax made storage the most economic option**
- ✓ **Research from SACS programme confirms that geological CO<sub>2</sub> storage can be done safely**
- ✓ **Research continues with CO2STORE and other programmes**
- ✓ **Discussion on legal aspects of geological CO<sub>2</sub> storage is ongoing, and is moving towards acceptance?**