

Ongoing research about CO₂ storage in StatoilHydro

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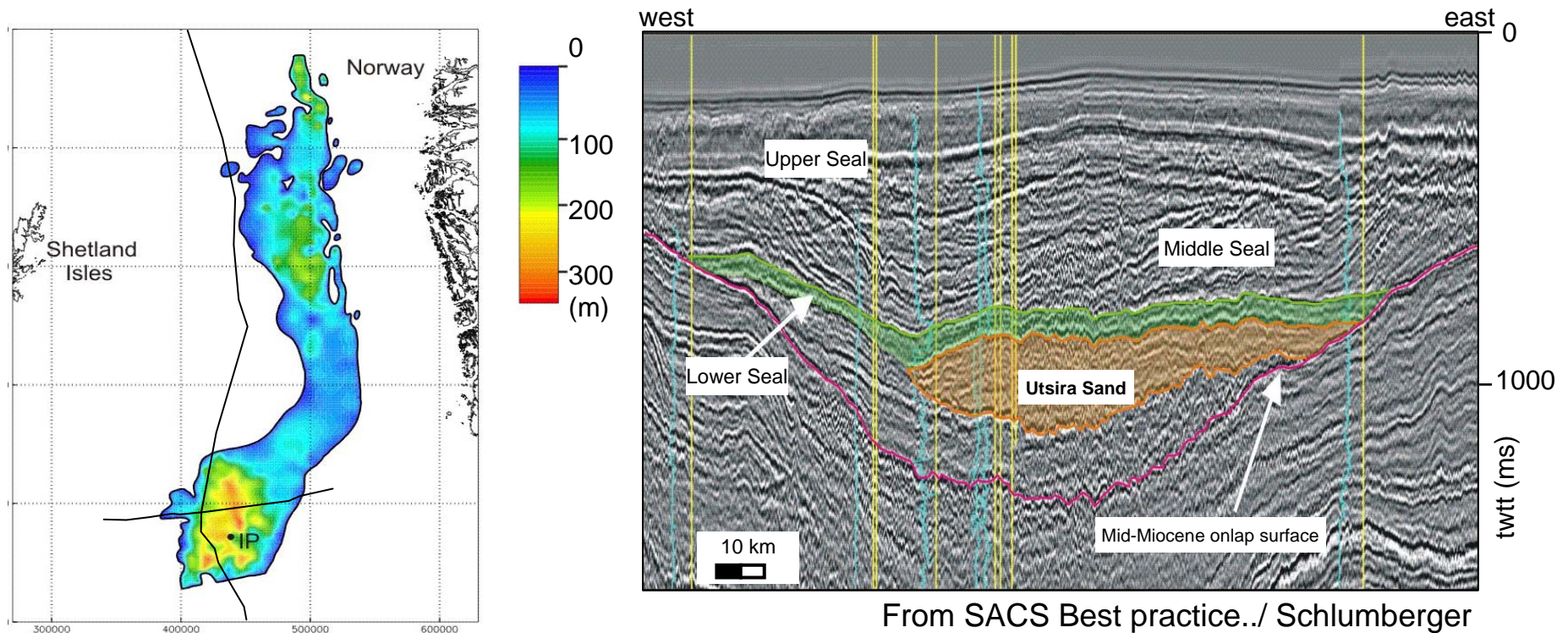
Main activities

- Storage potential
- Seismic modeling
- Sleipner chimney
- Sand injections
- Monitoring
- CO₂ storage sites:
 - Sleipner, Norway
 - Snøhvit, Norway
 - In Salah, Algeria

Storage potential on the Norwegian shelf

- Traps:
 - Abandoned fields
 - Undrilled structures
 - Dry structures
 - Storage outside structural closures
- Areas:
 - Utsira Fm.
 - Tampen megaclosure
 - Trænabanken
 - Alpha structure, Haltenbanken
 - Abandoned fields

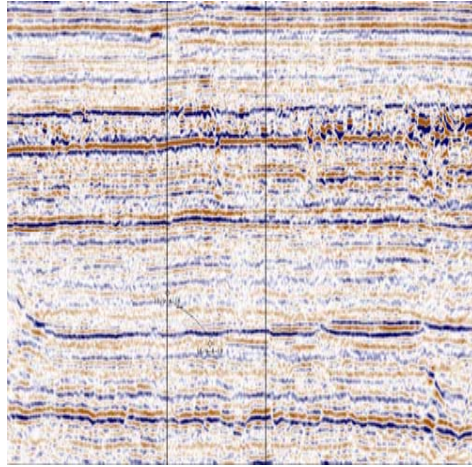
The Utsira Formation with Sleipner



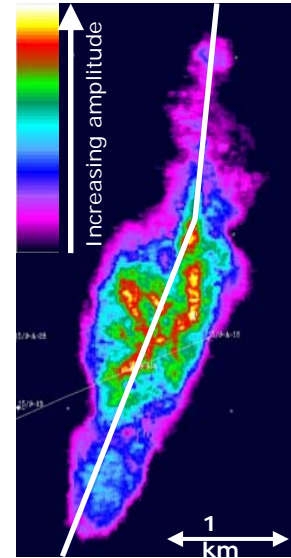
Structural closures: 0.1% of rock volume

Seismic monitoring of Sleipner CO₂ injection

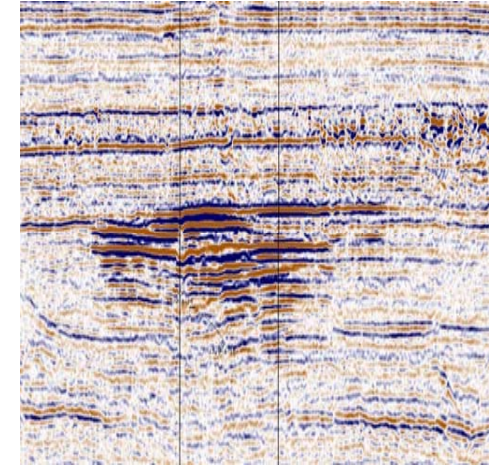
1994



- 8,4 million tonnes injected in period 1996-2006
- Area of CO₂ plume: 2,8 km²
- Length of CO₂ plume: 3760 m



2006



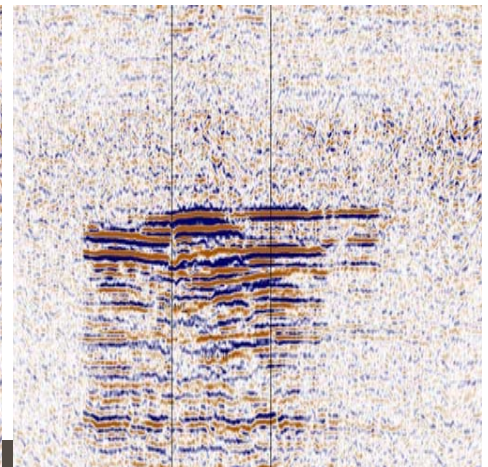
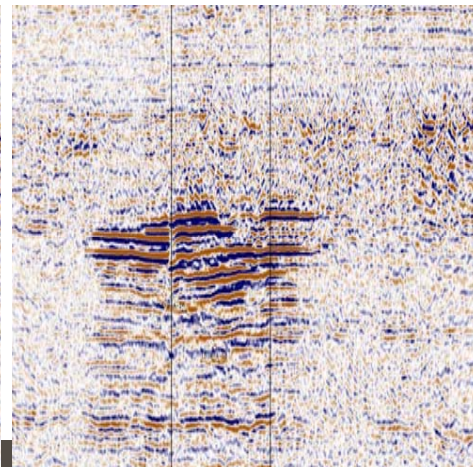
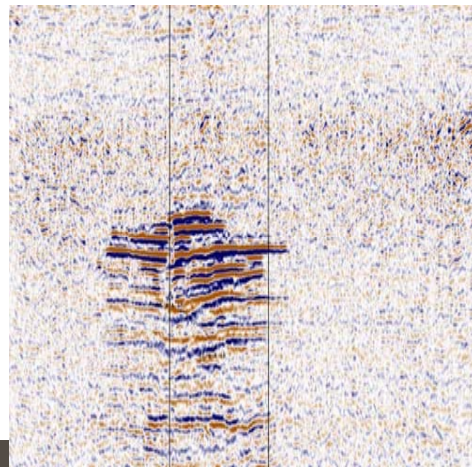
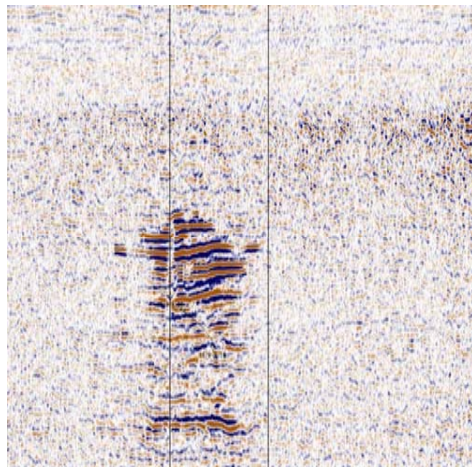
1999-1994

← 2 km →

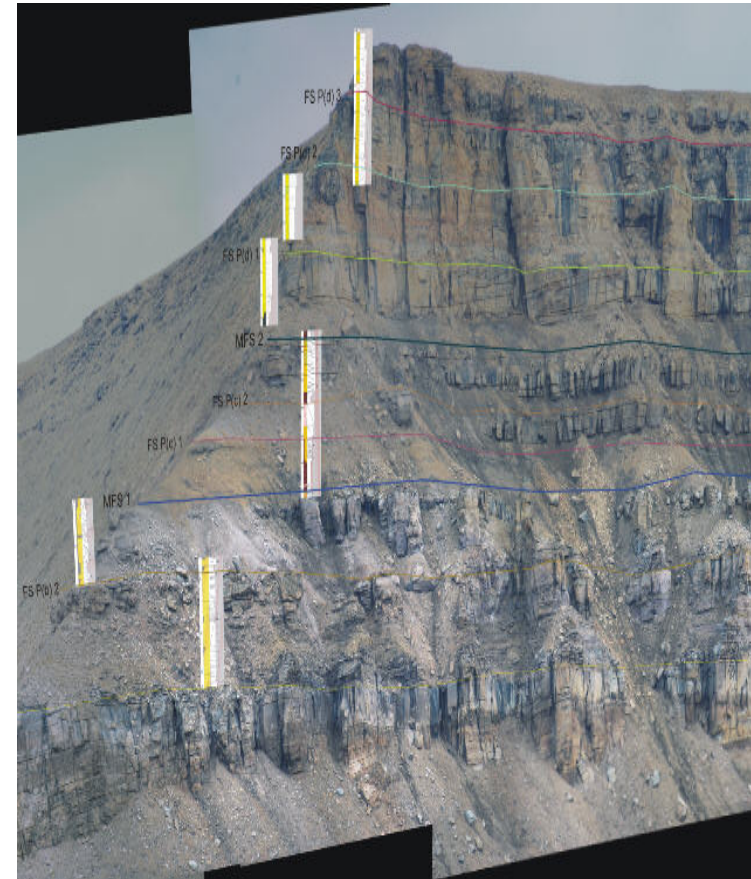
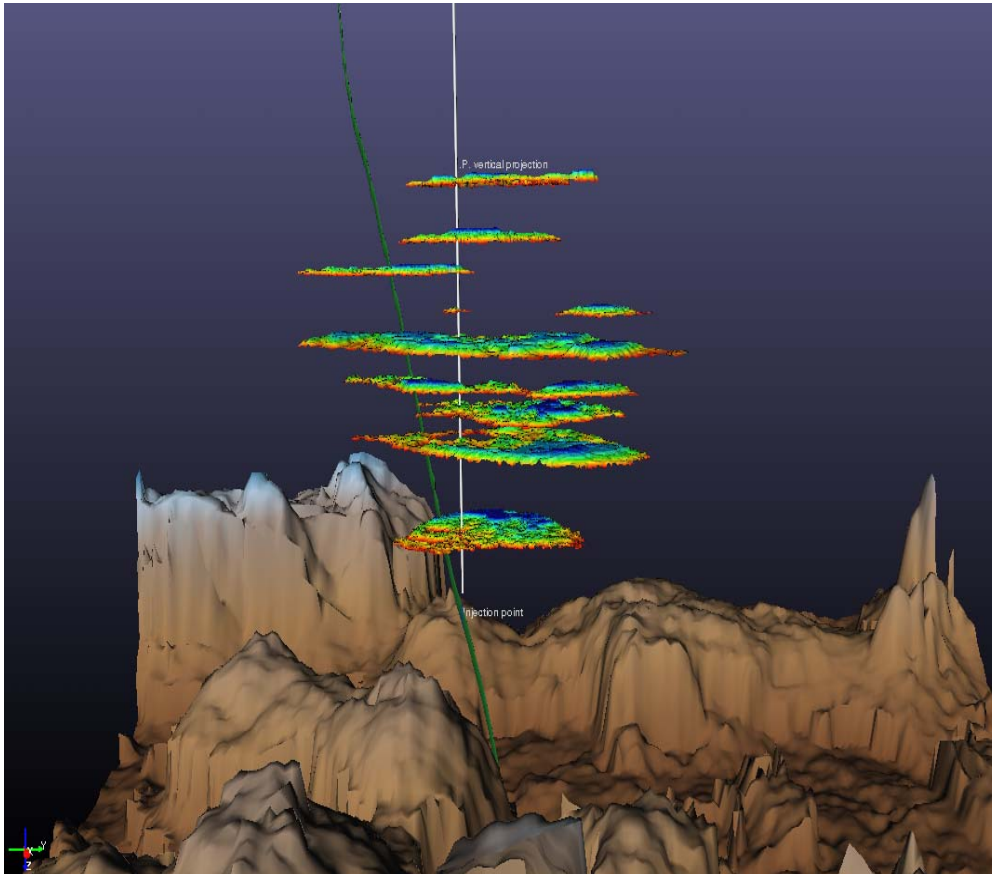
2001-1994

2004-1994

2006-1994

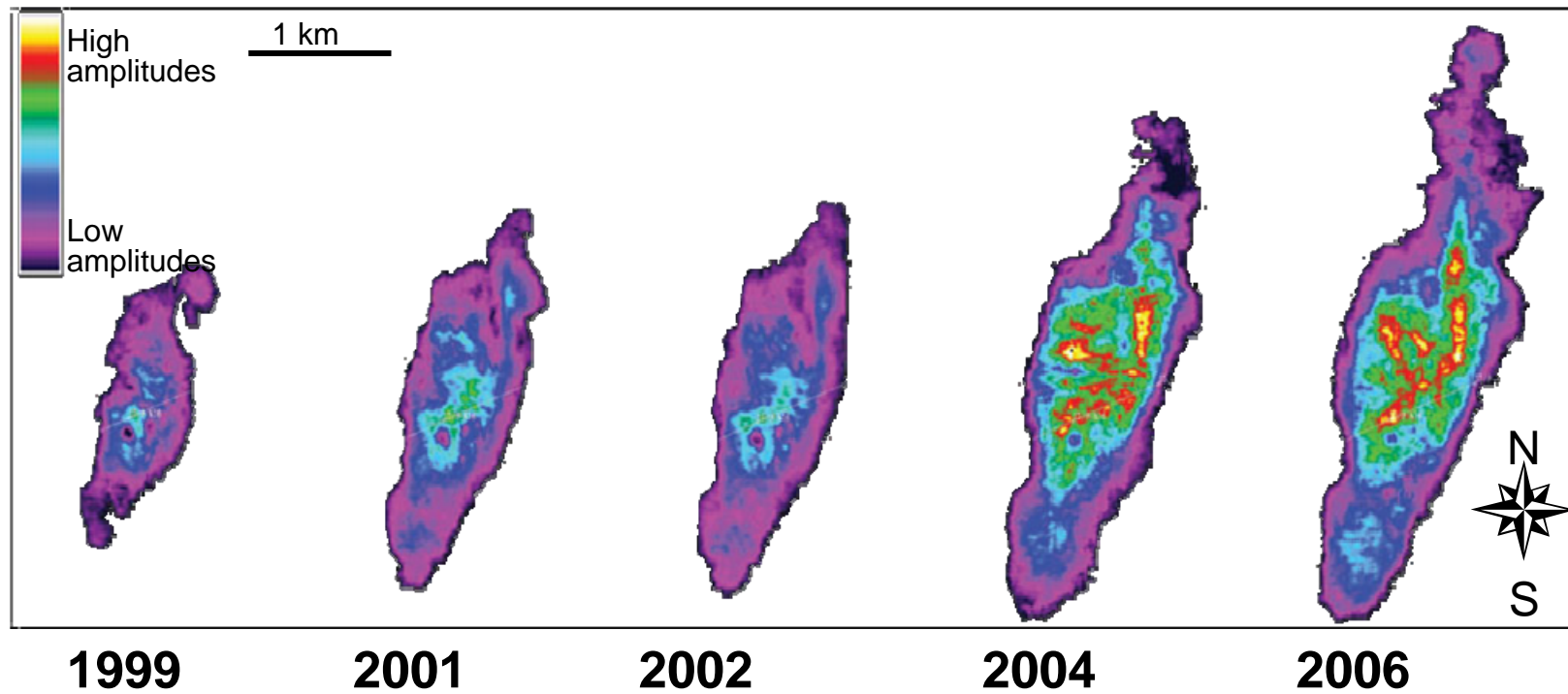


Vertical CO₂ distribution

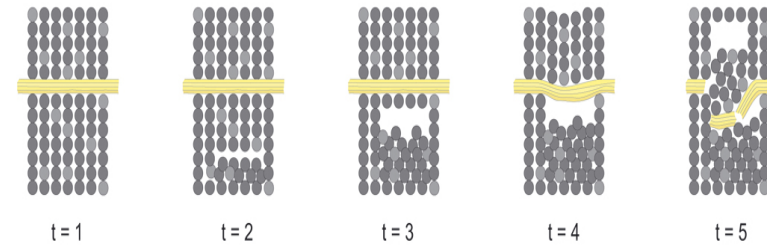


2/3 of the CO₂ in layers 1 – 7: below mapped closure

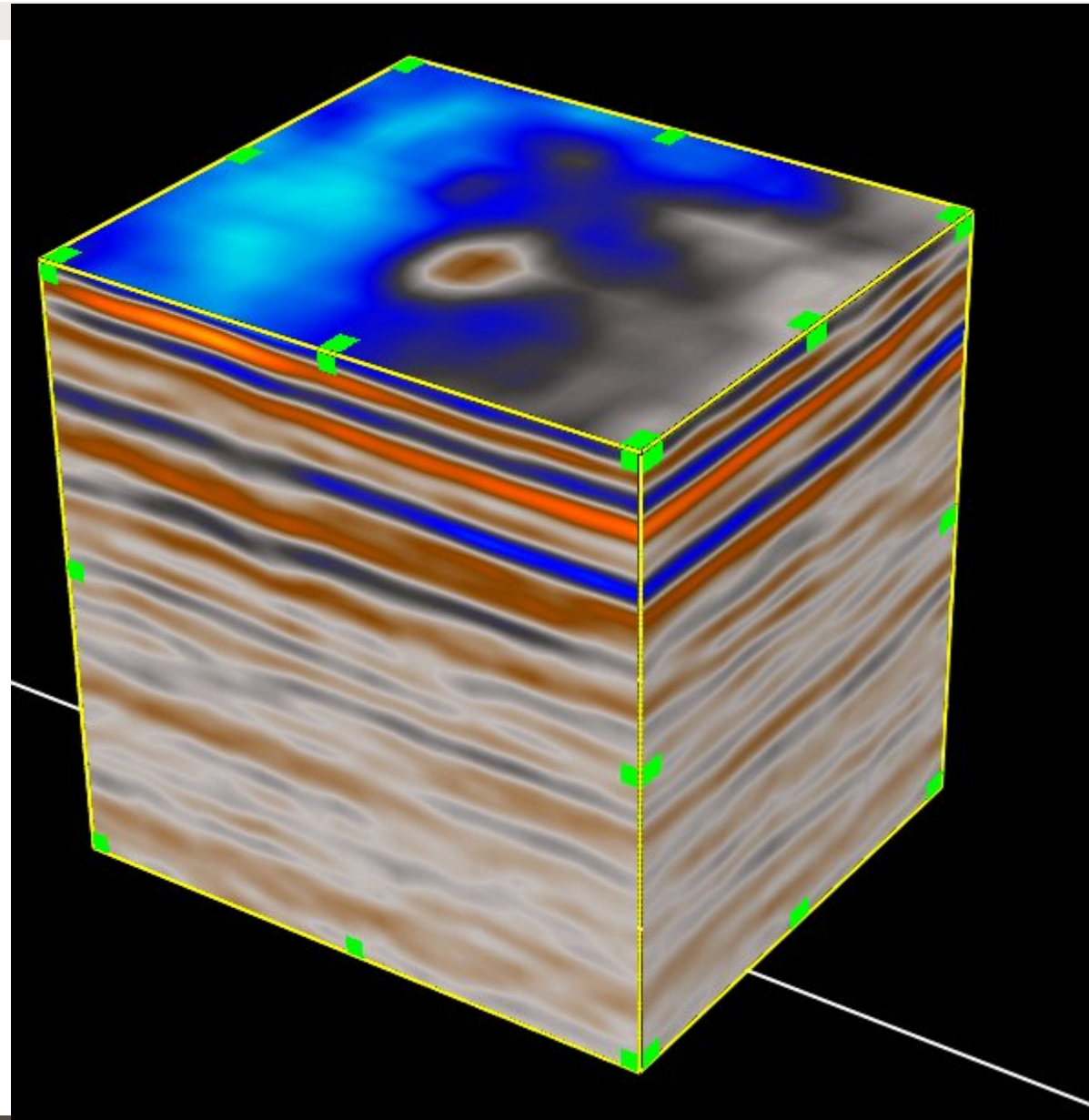
CO₂ distribution – with chimney



How was the chimney created?



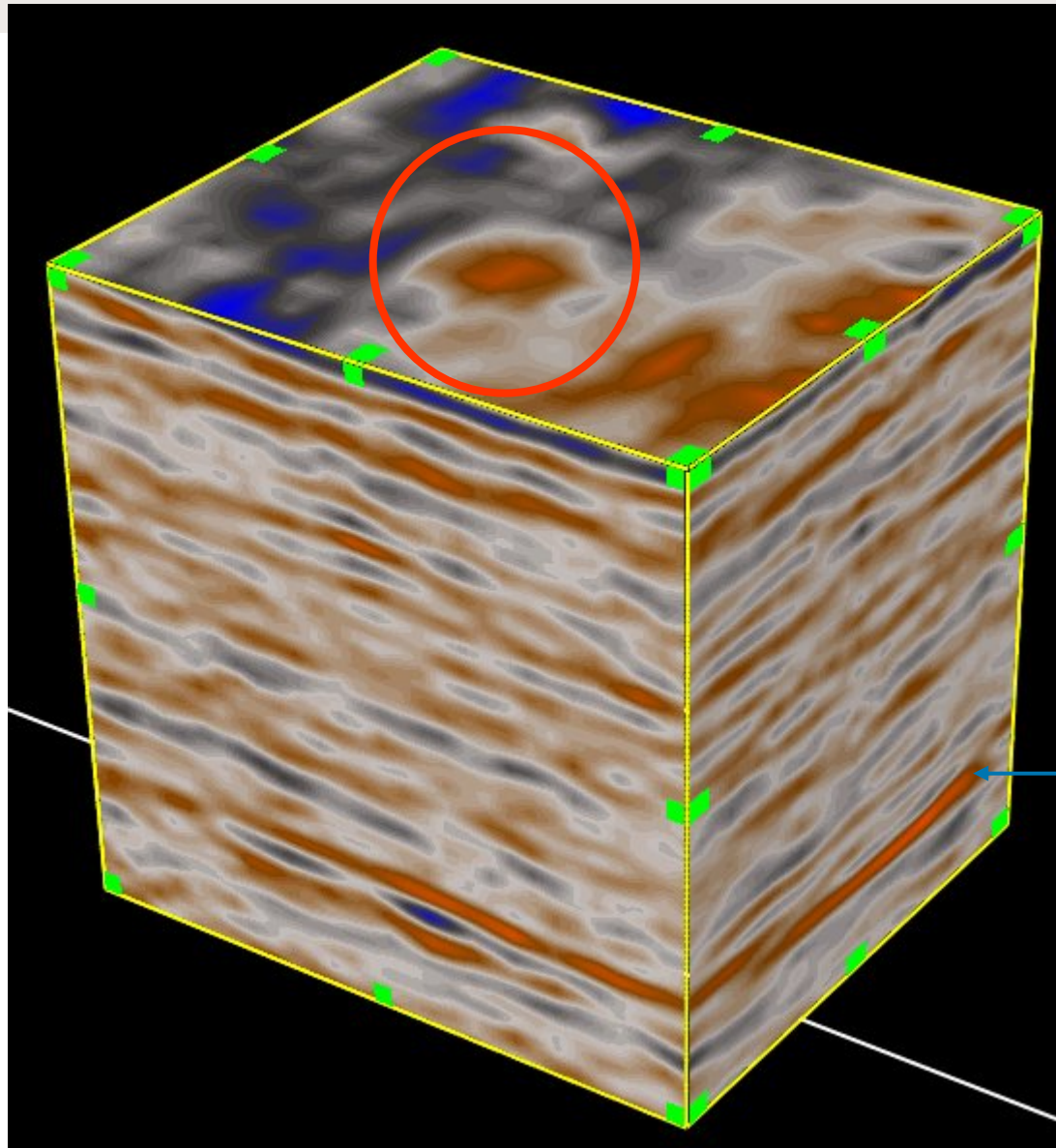
2006



1994

Modified
color scale

Origin of
circular
event?

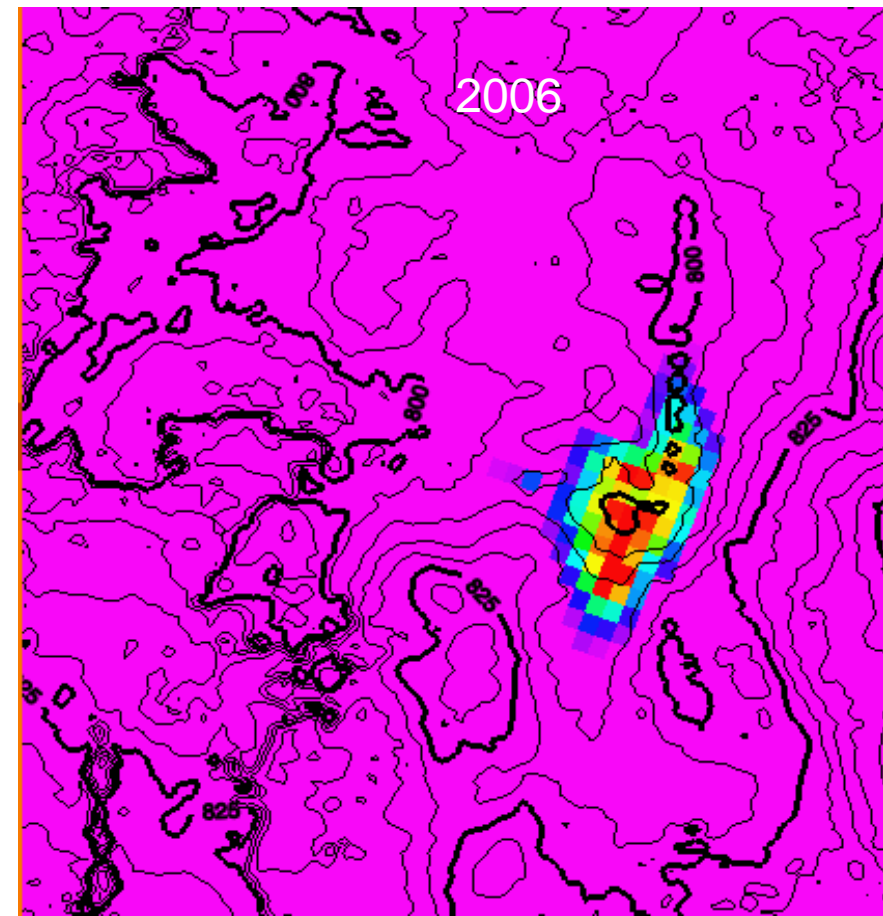
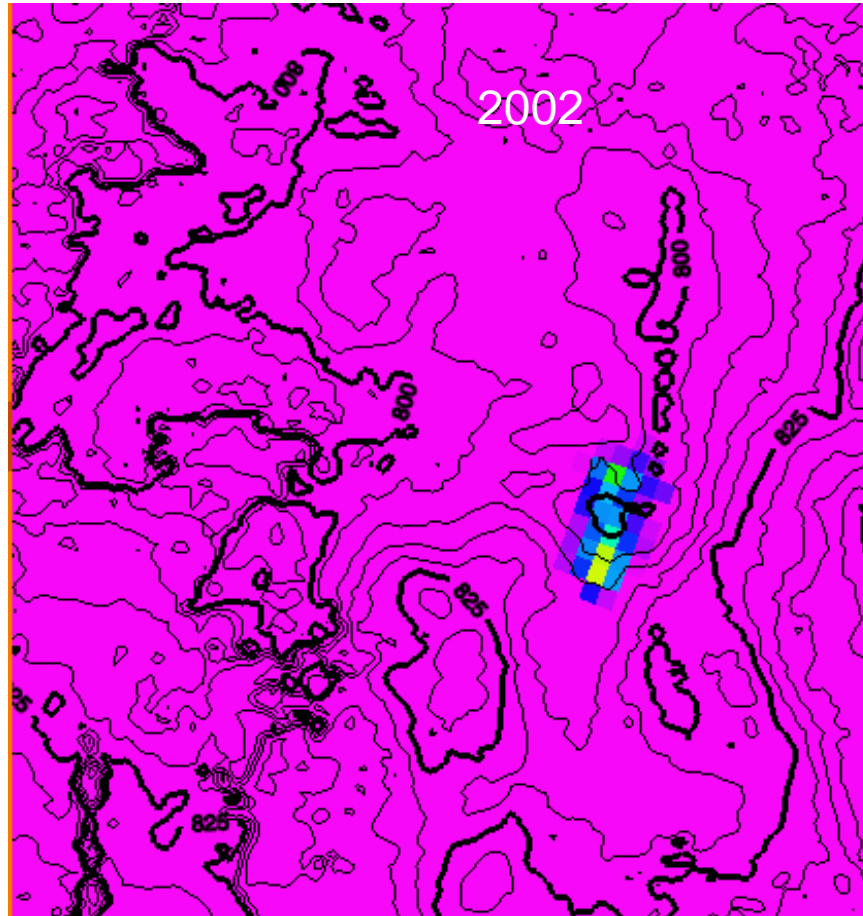


Base Utsira

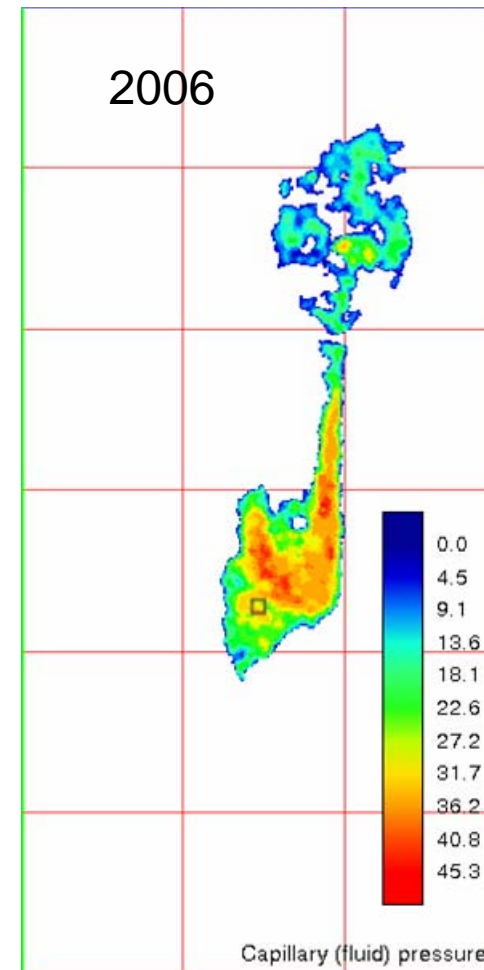
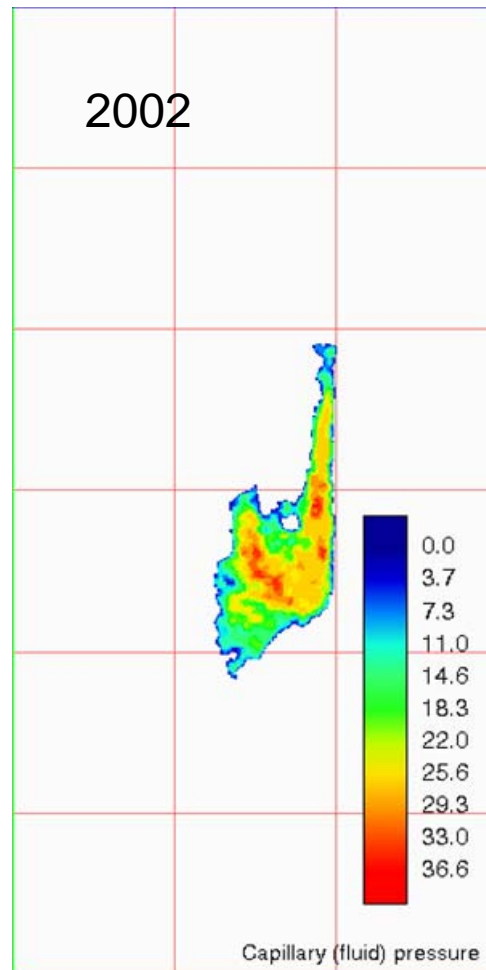
Sleipner reservoir modelling

- Darcy flow
 - Modelled by Sleipner reservoir asset team
 - Eclipse black oil reservoir model with CO₂ as oil
- Invasion percolation modelling
 - Modelled by Permedia using Mpath
 - Mpath originally designated for modelling of secondary migration of oil

Eclipse model results year 2002 and 2006

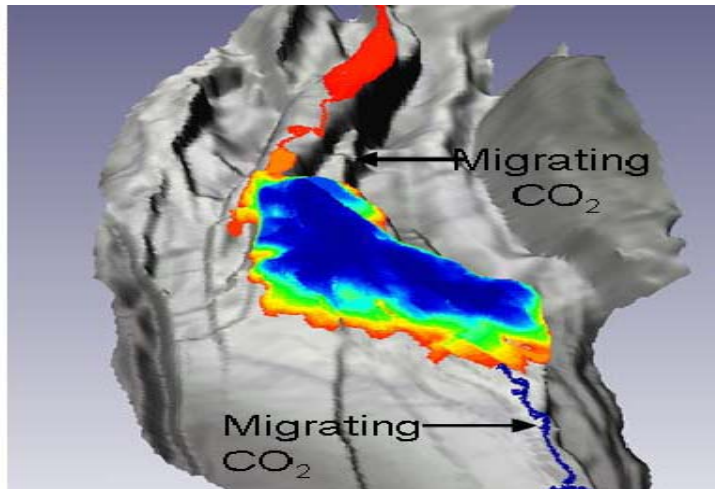


Mpath (Permedia) model: Results year 2002 and 2006

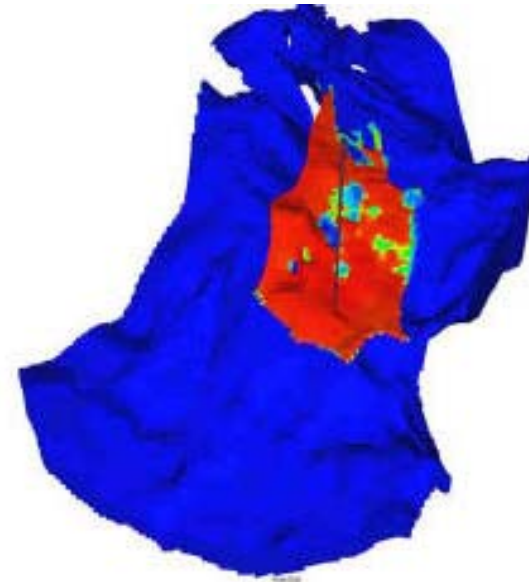


Choice of modelling tools may influence the simulation results.

- And ultimately the CO₂ storage site choice?**



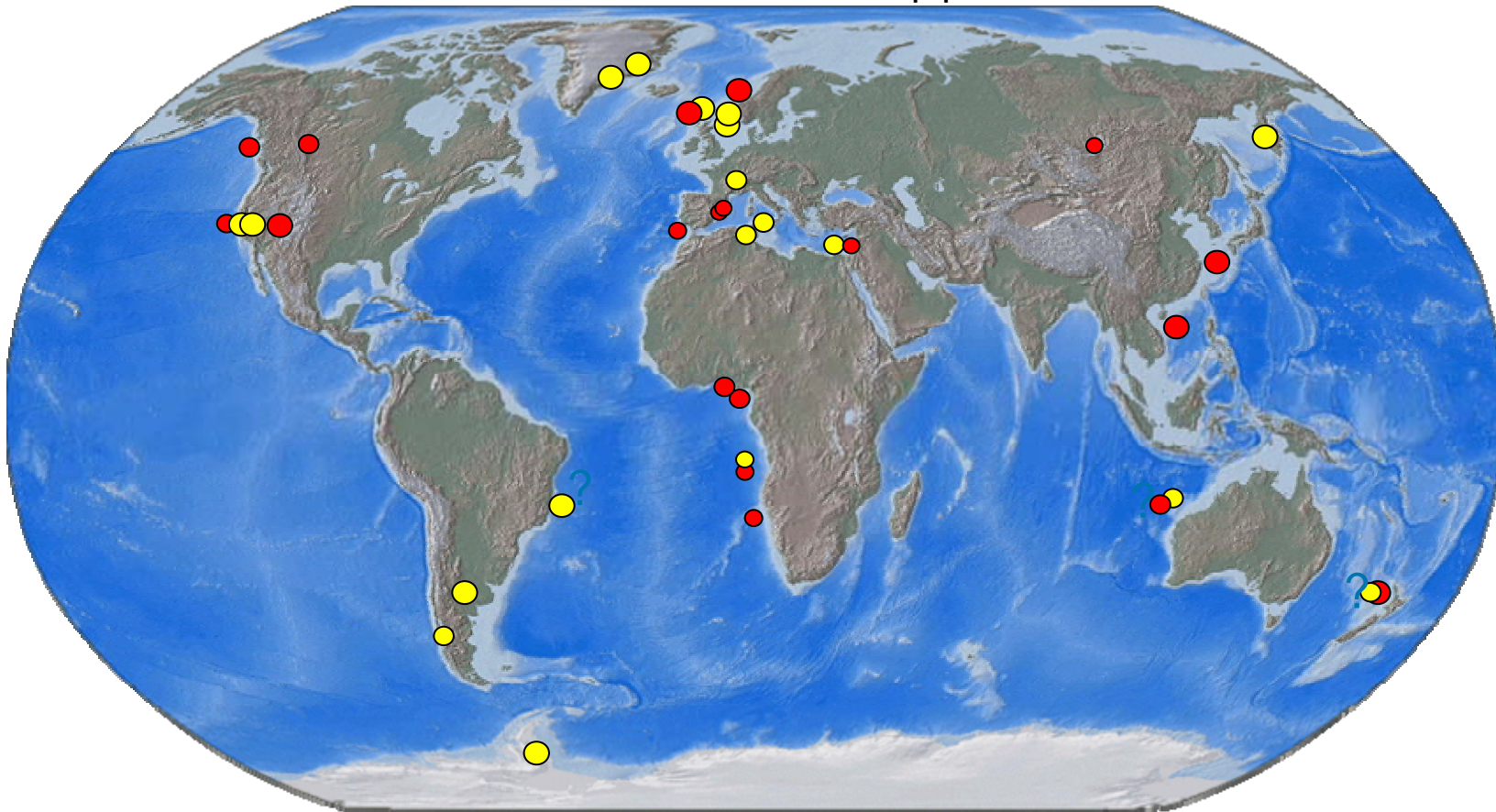
Pc flow



Darcy flow

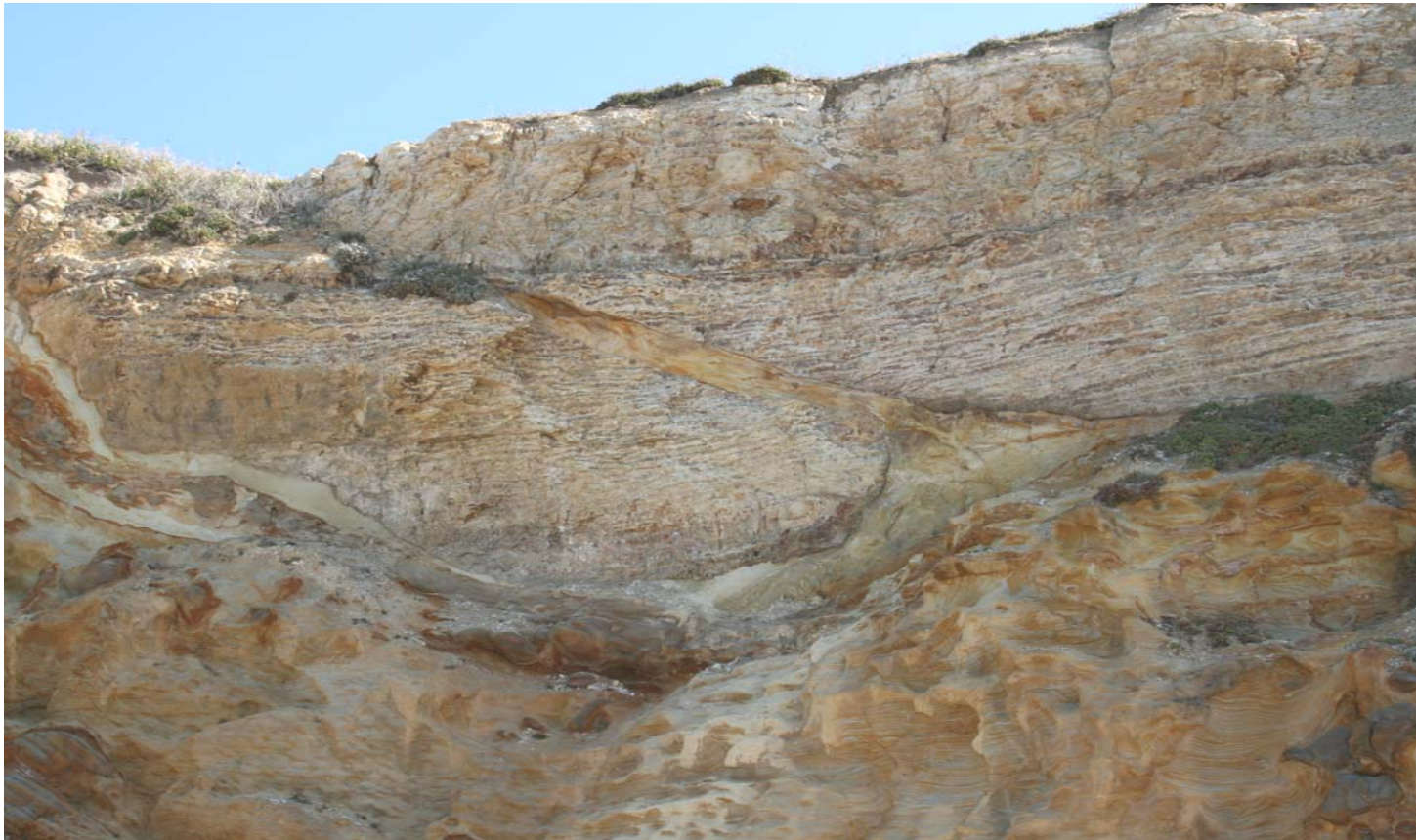
Occurrence of sandstone intrusion systems

- Sandstone intrusion networks
- Blow-out/fluidization pipes



Santa Cruz - California

Sand injection

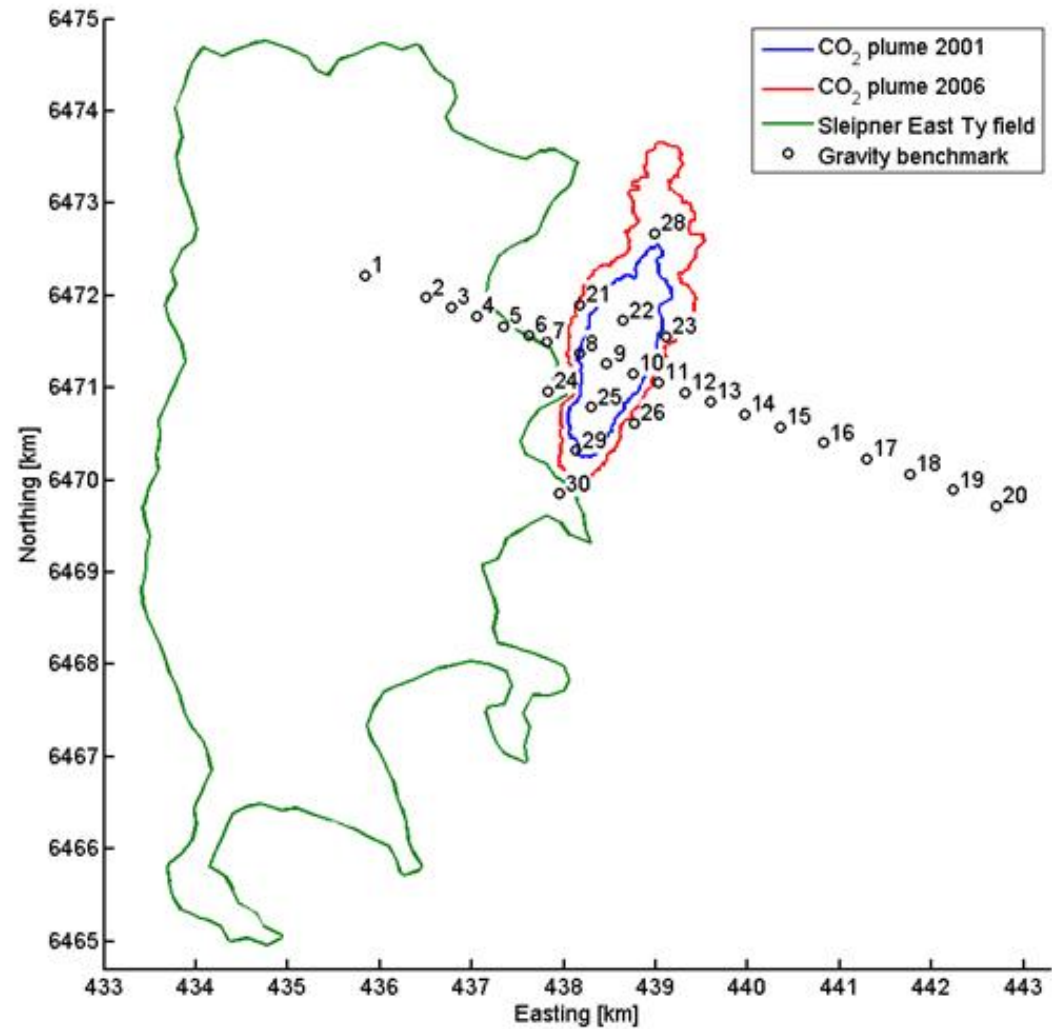


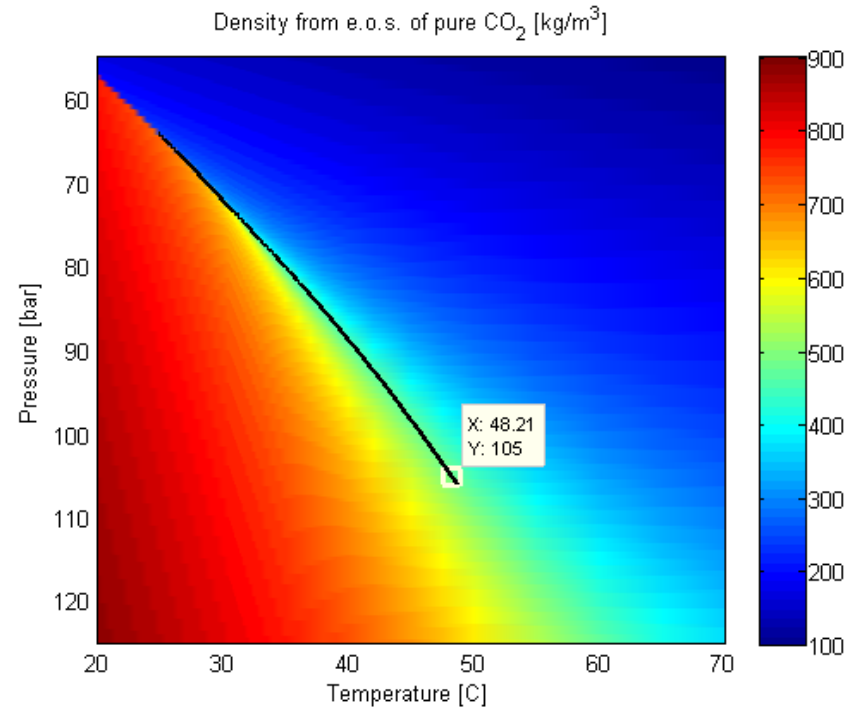
Panoche - California

- Sand injections



Gravimetry measures in-situ CO₂ density

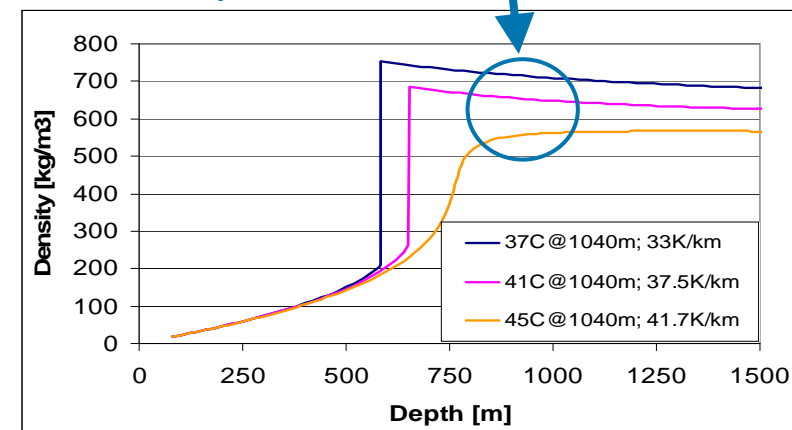




CO₂ density: 760 ± 60 kg/m³

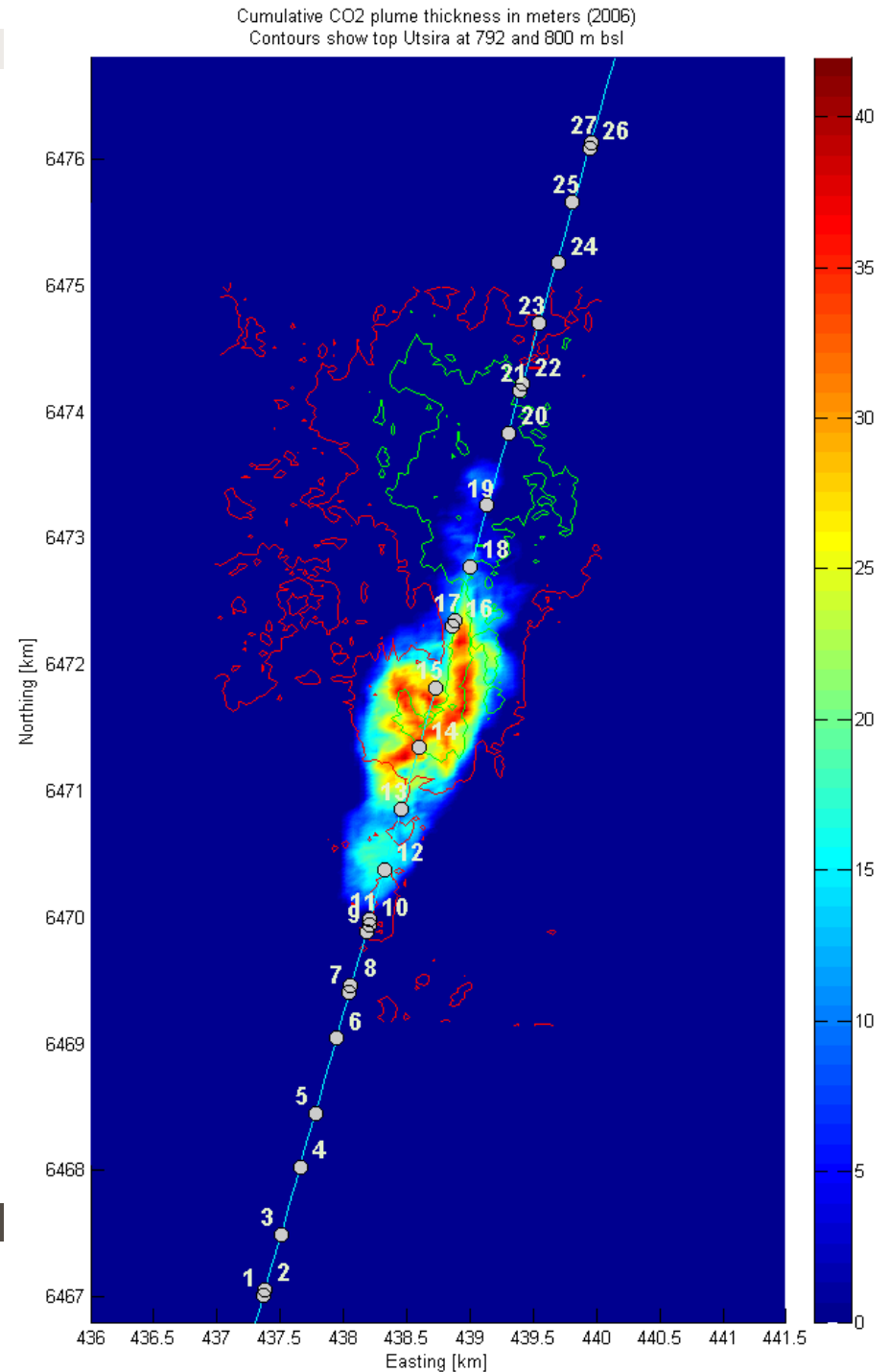
- Different temperature estimates give very different values for the density of CO₂ in situ
- Time-lapse gravimetry can tell the difference

Sleipner/Utsira conditions



Controlled Source ElectroMagnetic survey – September 2008

- One line along the “long” axis of the plume.
- 27 receivers at 20 locations –
 - 500m between receiver locations
 - 50m between “doubled” receivers

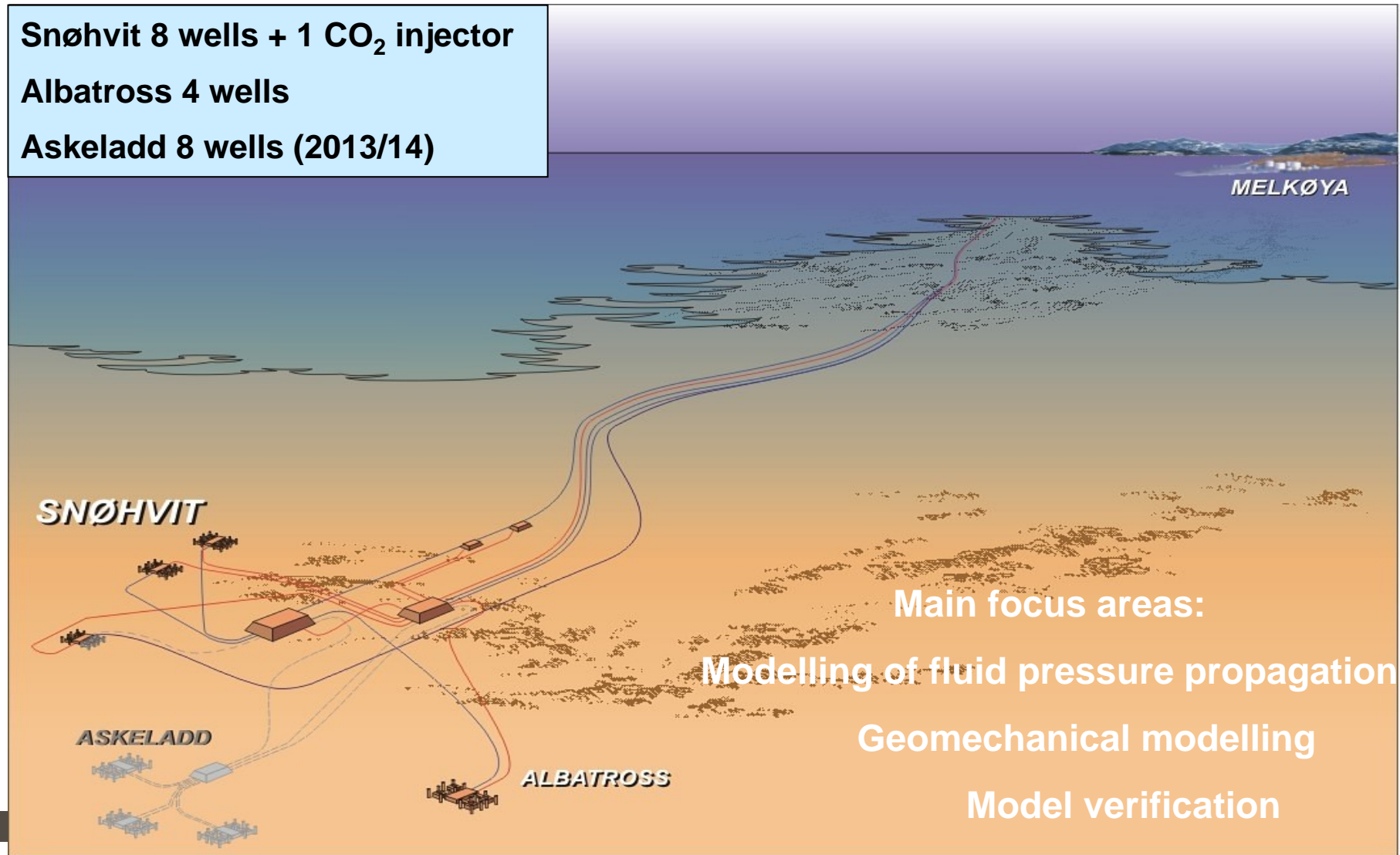


Snøhvit

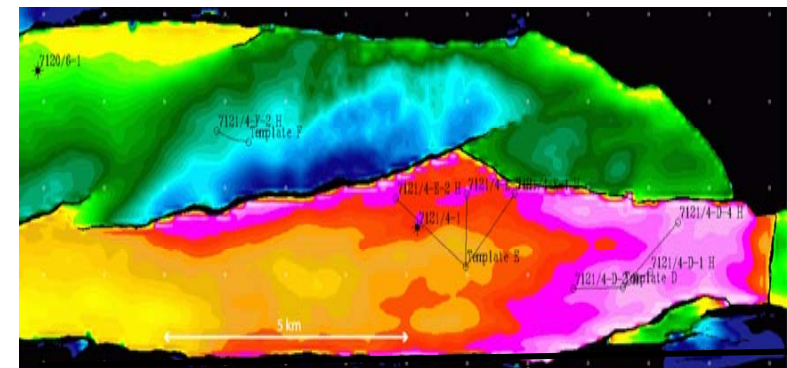
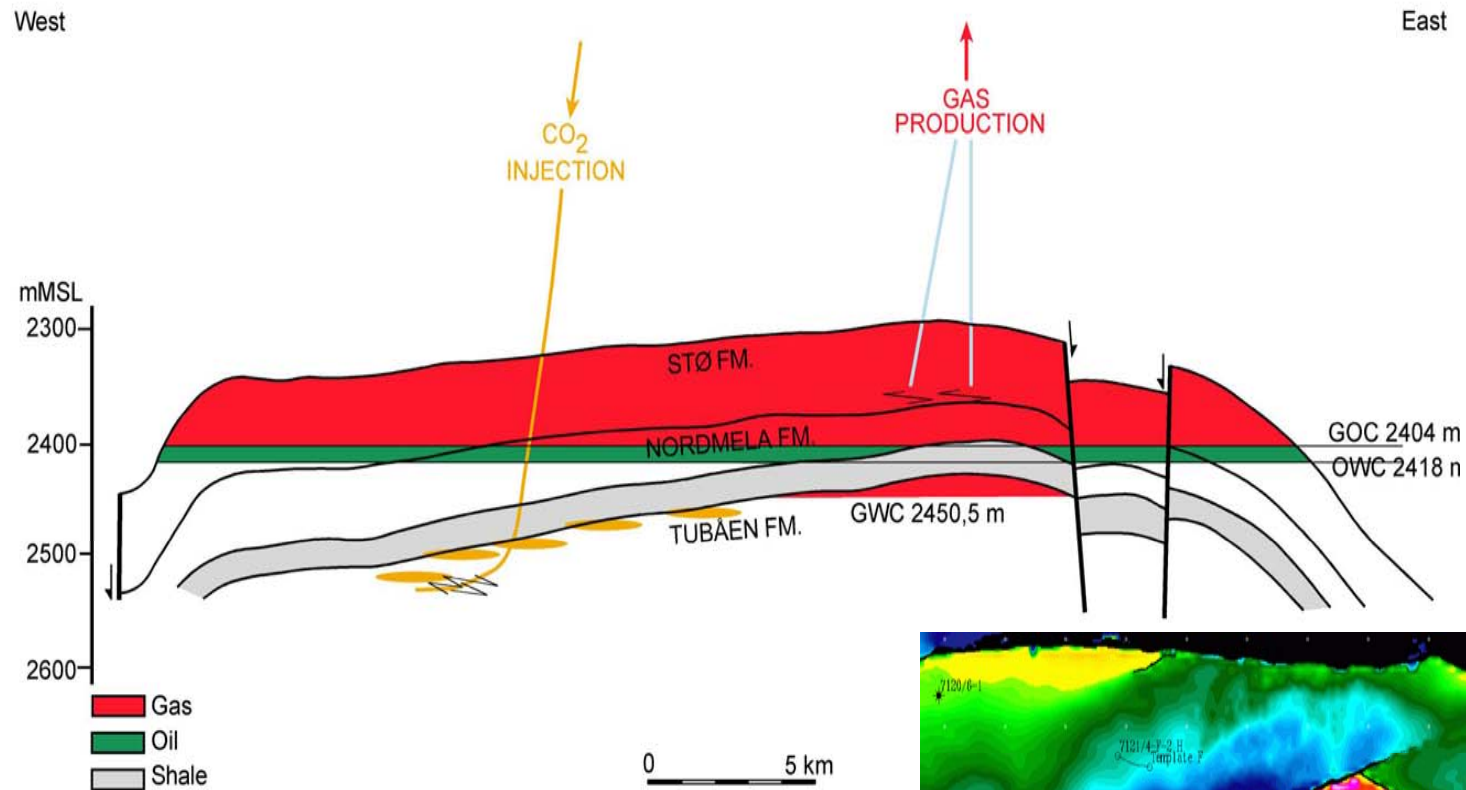
Snøhvit 8 wells + 1 CO₂ injector

Albatross 4 wells

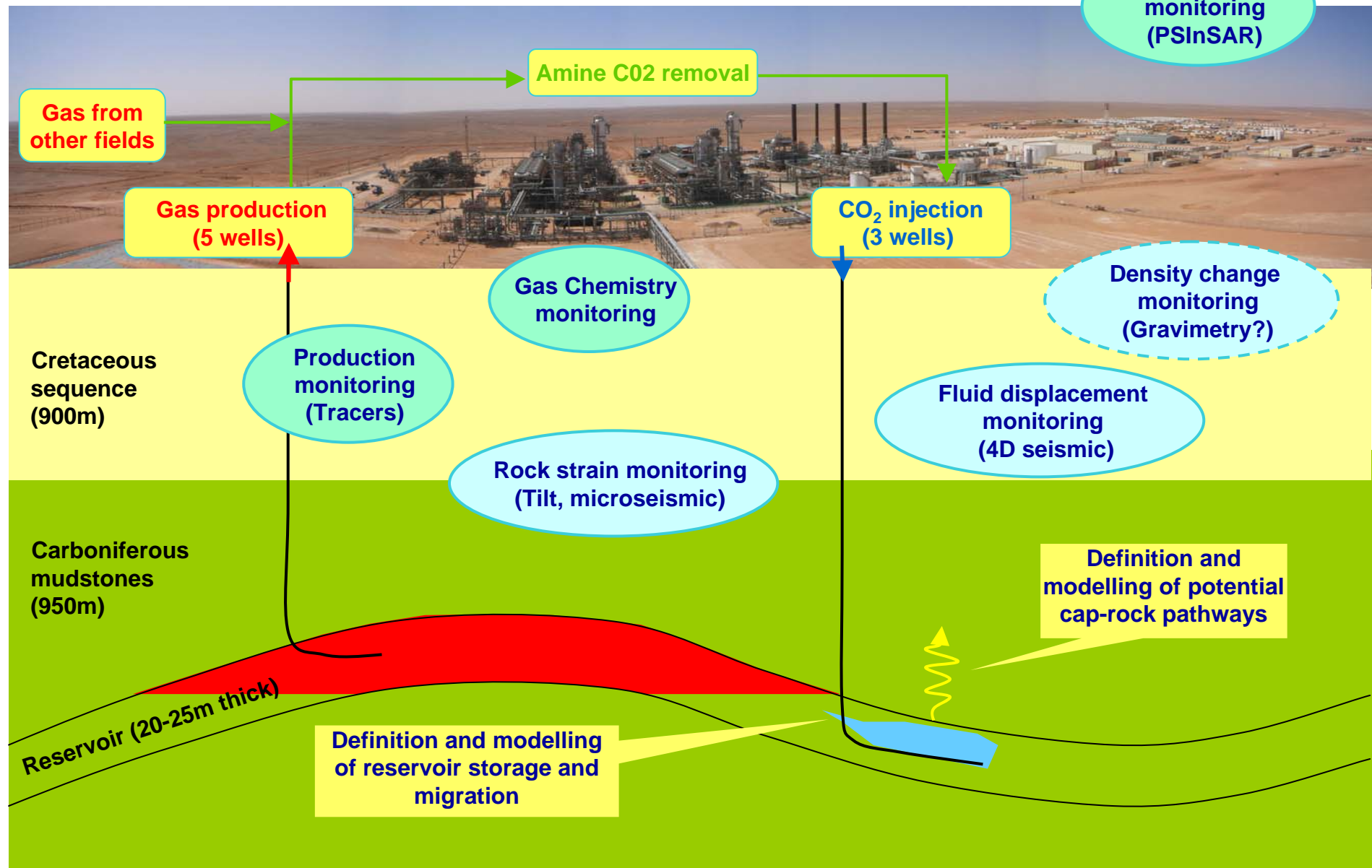
Askeladd 8 wells (2013/14)



Reinjecting up to 700,000 tons CO₂/year CO₂ injection started spring 2008



The In Salah CO₂ storage site at Krechba



The Road ahead for Underground Storage

StatoilHydro is currently involved in storing CO₂:

- **Offshore** (Sleipner and Snøhvit) and **onshore** (In Salah)
- **Below, above and within** the producing formation

StatoilHydro will continue to research injection and storage issues related to these topics.