Norwegian Experience from CCS Operations

CCS: Pathways to Commercialisation.

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CCS Operations at Statoil

- Statoil is a world leading operator of CCS sites
- The pioneering Sleipner project started in 1996
- Unique blend of experience from several operations
- 22 Mt CO_2 stored safely underground

Sleipner

1996

In Salah

2004

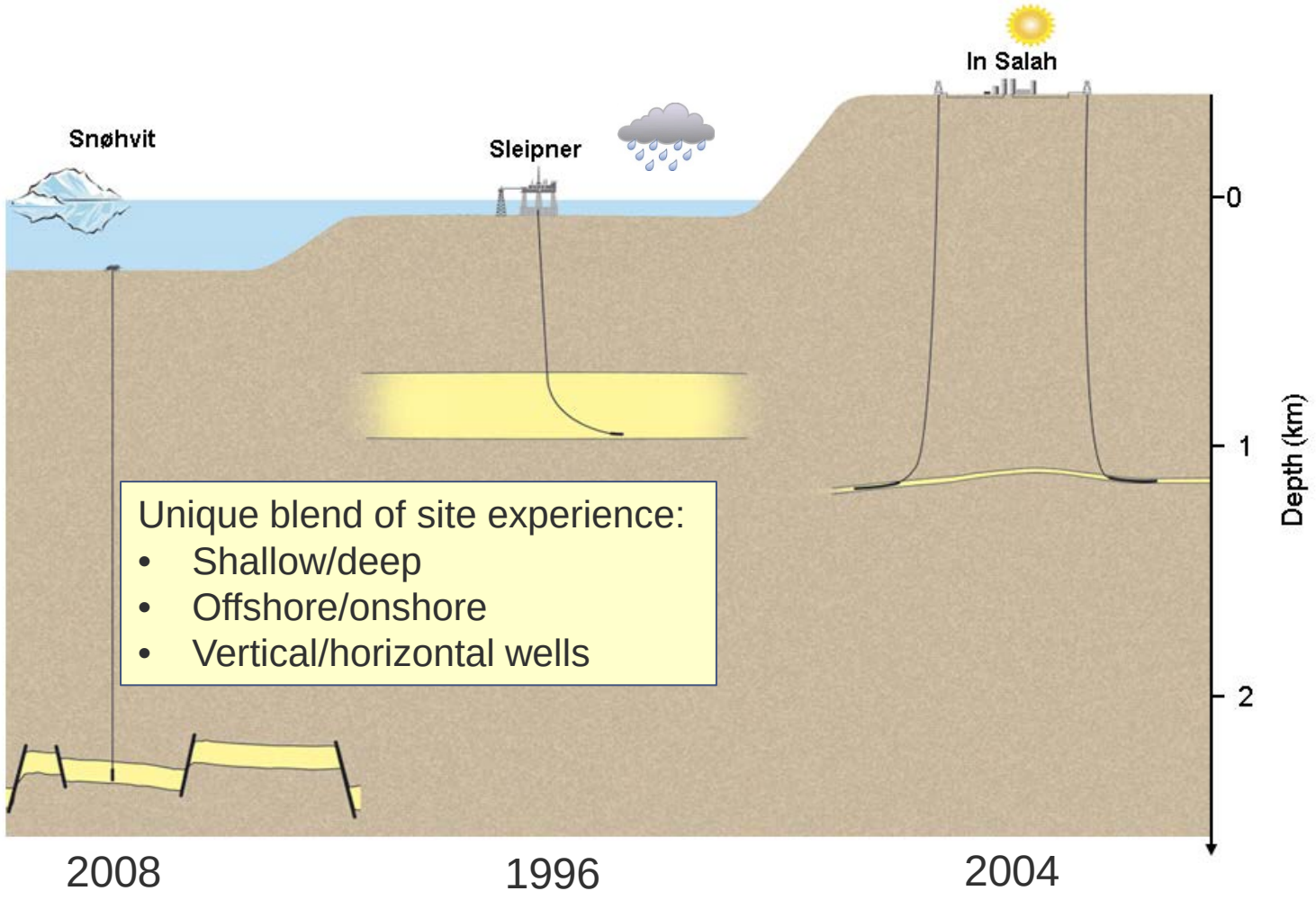
Snøhvit LNG

2008

Test Centre Mongstad

2012

Statoil storage projects



Eiken et al., 2011

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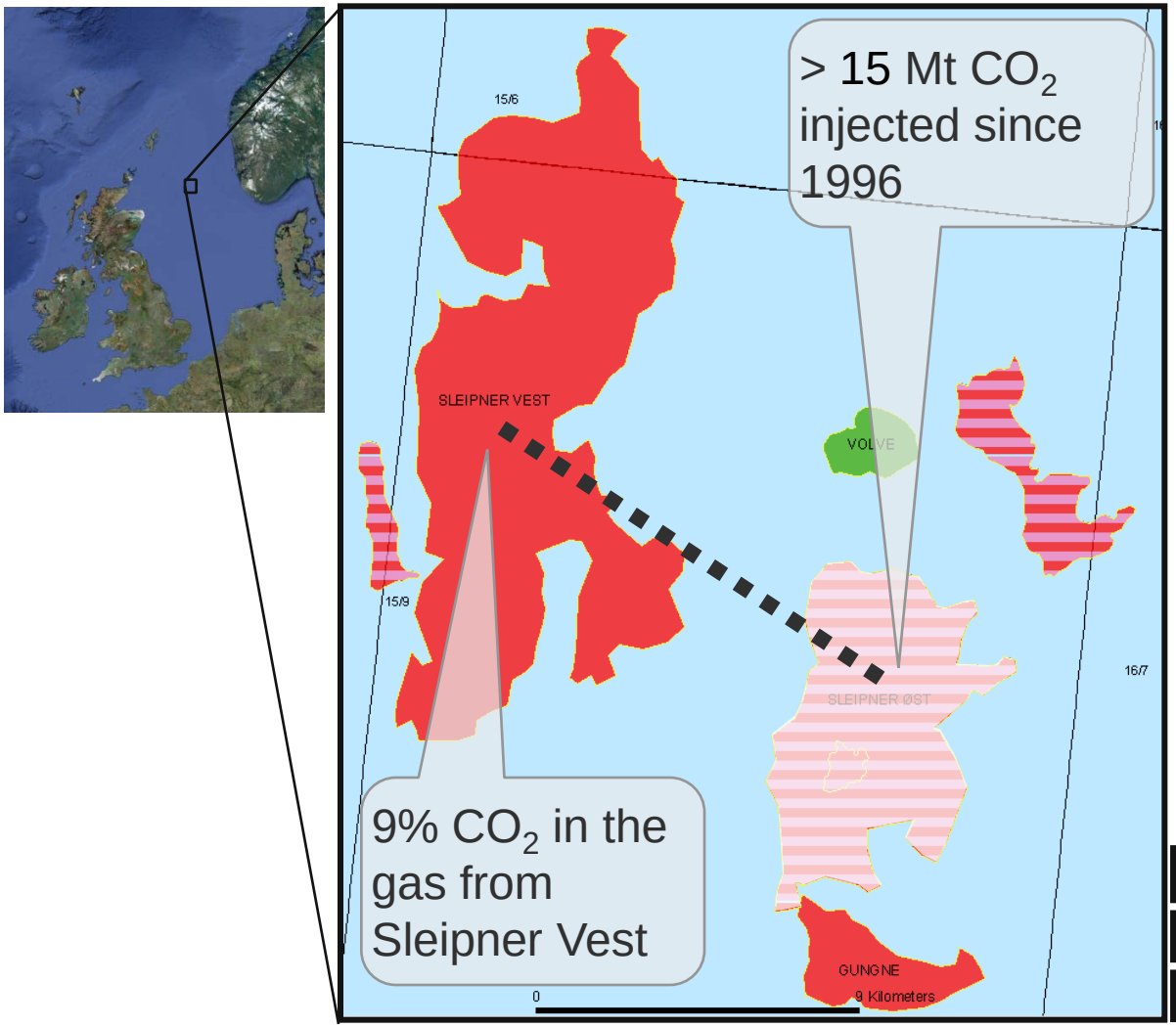
Sleipner fields



Sleipner West: Gas field with high CO_2 content.

Sleipner East: CO_2 is stripped off the gas and injected in the Utsira Fm at ~ 900 m depth (above the condensate reservoir).

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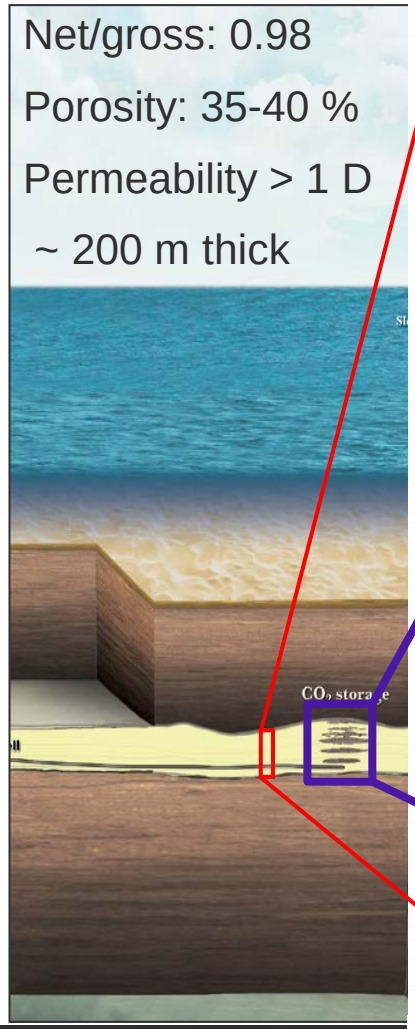
Sleipner – Utsira Formation

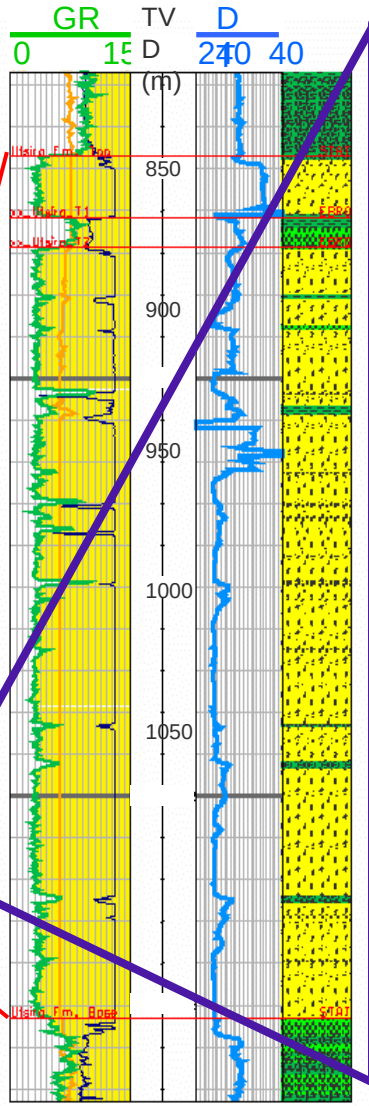
Net/gross: 0.98

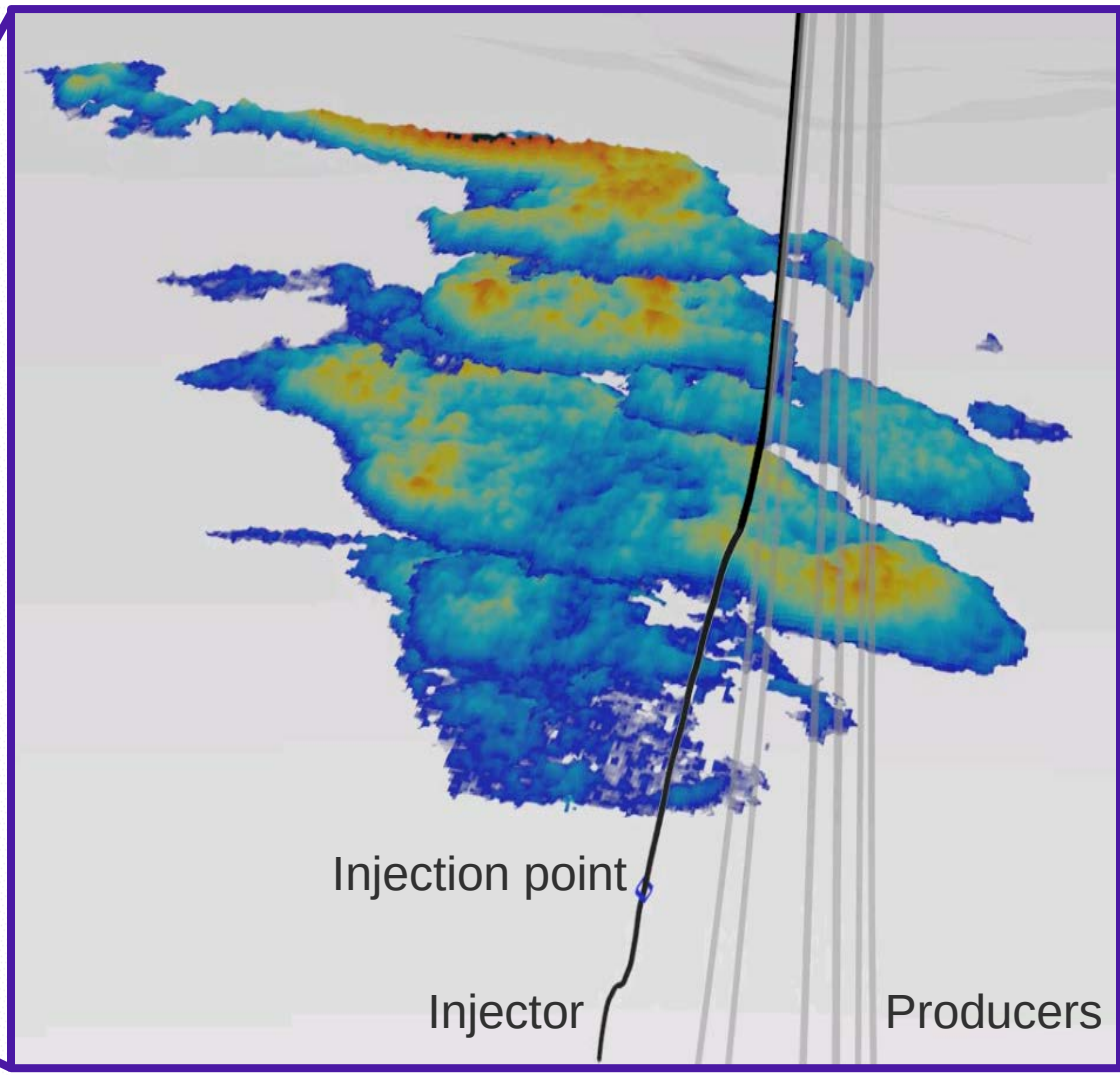
Porosity: 35-40 %

Permeability > 1 D

~ 200 m thick







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Sleipner Summary

- ***Main learning: CO_2 storage is technically feasible***

- **The World's first commercial-scale offshore storage project**
  - Storage unit: 800-1000 m depth, 200 m thick, high permeability
  - More than 15 Mt CO_2 has been injected since 1996
- **Challenges:**
  - Role of internal shale layers on plume movement
  - Predicting CO_2 plume flow properties
- **Take-aways:**
  - CO_2 plume can be monitored by seismic and gravimetric methods
  - Significantly improved understanding of CO_2 storage processes

In Salah Project

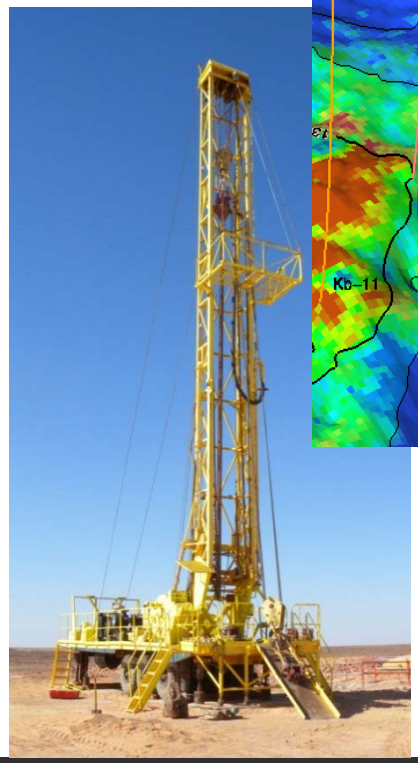
- In Salah is multiple gas field development project in central Algeria
- CO_2 contents in the gas fields ranges between 1% and 10%
- CO_2 separated and injected into the down-dip aquifer of the Carboniferous sandstone at Krechba
- CO_2 Injection started in 2004 and over 4 Mt of CO_2 stored underground
- A comprehensive monitoring programme
- Several important lessons learned

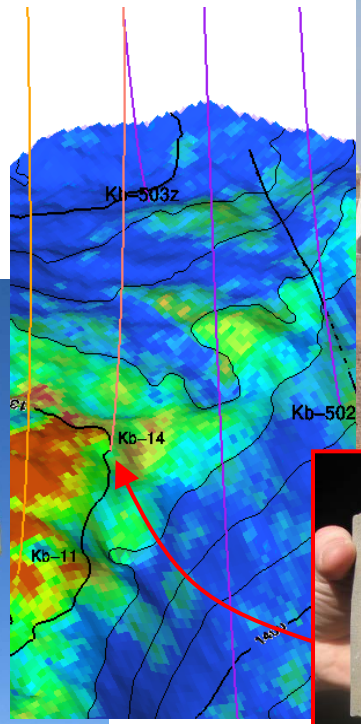
In Salah Gas
Stockage de CO_2

In Salah CO_2 Monitoring Programme

Wide range of monitoring data collected:

- **Time lapse (4D) seismic**
- **Wellhead measurements**
- **Subsurface data**
- **Observation wells**
- **Surface Measurements**
- **Satellite InSAR Surveys**





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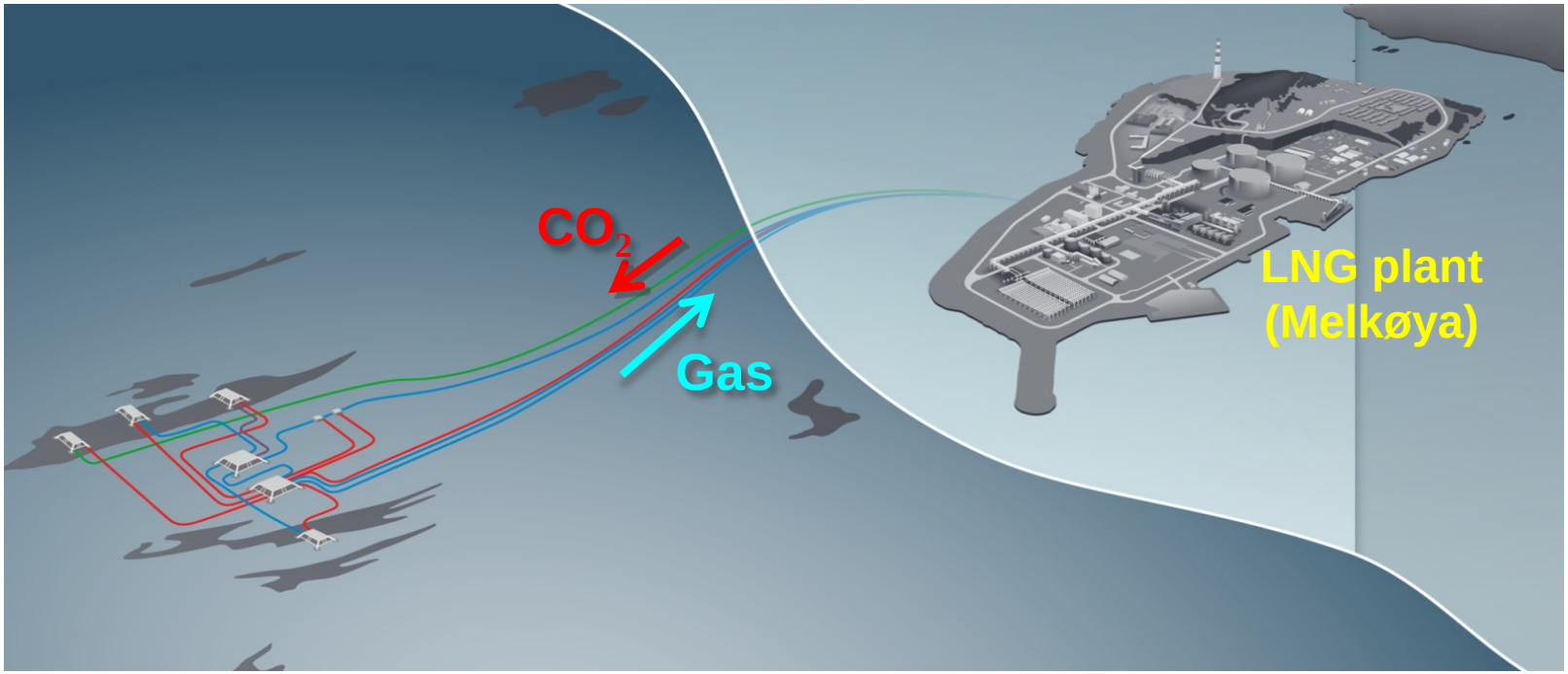
Snøhvit

➢ *First onshore capture - offshore storage project (combined with LNG)*

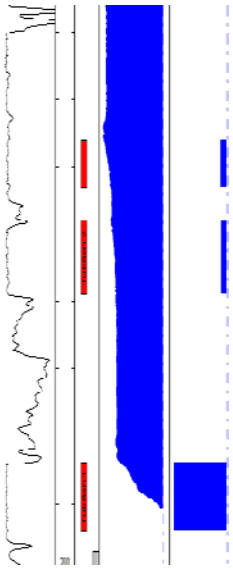
- 150km seabed CO_2 transport pipeline
- Saline aquifers c. 2.5km deep adjacent to gas field
- CO_2 stored initially in the Tubåen Fm. and then in the Stø Fm. (2011-)



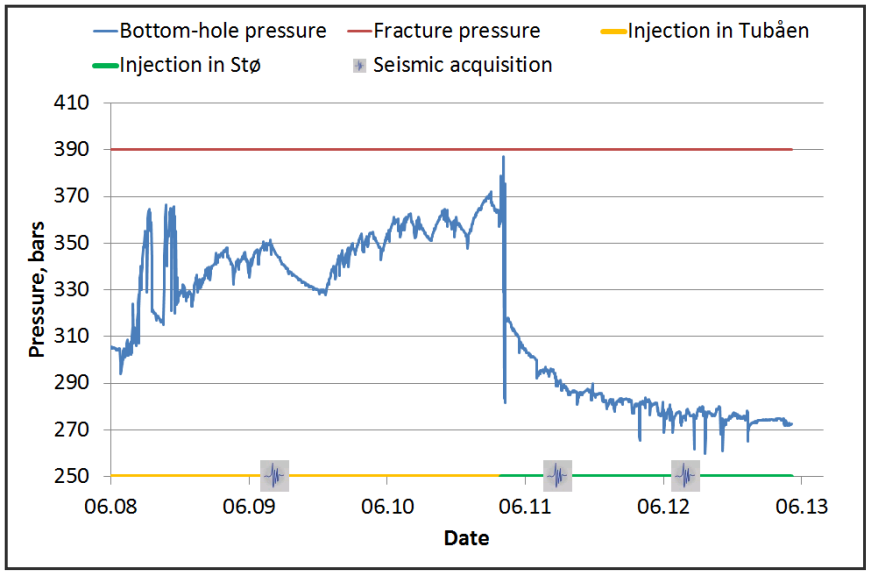
Monitoring Techniques applied at Snøhvit

- 4D Seismic
- Downhole P/T gauges and flow logging
- Gravity surveys

Down-hole data:
P, T, Q



Down-hole pressure data



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Snøhvit Summary

- **Main learning: integrating geophysics and reservoir management**

- **The world's first offshore CO_2 transport pipeline**
  - Distance: field-to-onshore facility is 150 km
  - Storage unit: 2600 m depth
  - 3 Mt CO_2 has been injected since 2008
- **Challenges:**
  - Reservoir heterogeneity
  - Near-well flow limits
- **Take-aways:**
  - Need for robust design of injection system in heterogeneous reservoirs
  - A good 'Plan B' is invaluable when reservoir uncertainties are large

Main Lessons Learned

- 20-year track record in CO_2 storage operations
- Geophysical monitoring has proven essential for site management
  - ➢ Safe CO_2 storage confirmed
- Practical learnings about capacity and injectivity from well operations
- Improved understanding of CO_2 storage processes
  - ➢ Builds confidence in model forecasts
- Sharing experience is important for building confidence in CCS

There's never been a better time for good ideas

www..statoil.com

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