CO_2 pressure and migration modelling at different scales: from basin to reservoir

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Sintef Petroleum Research

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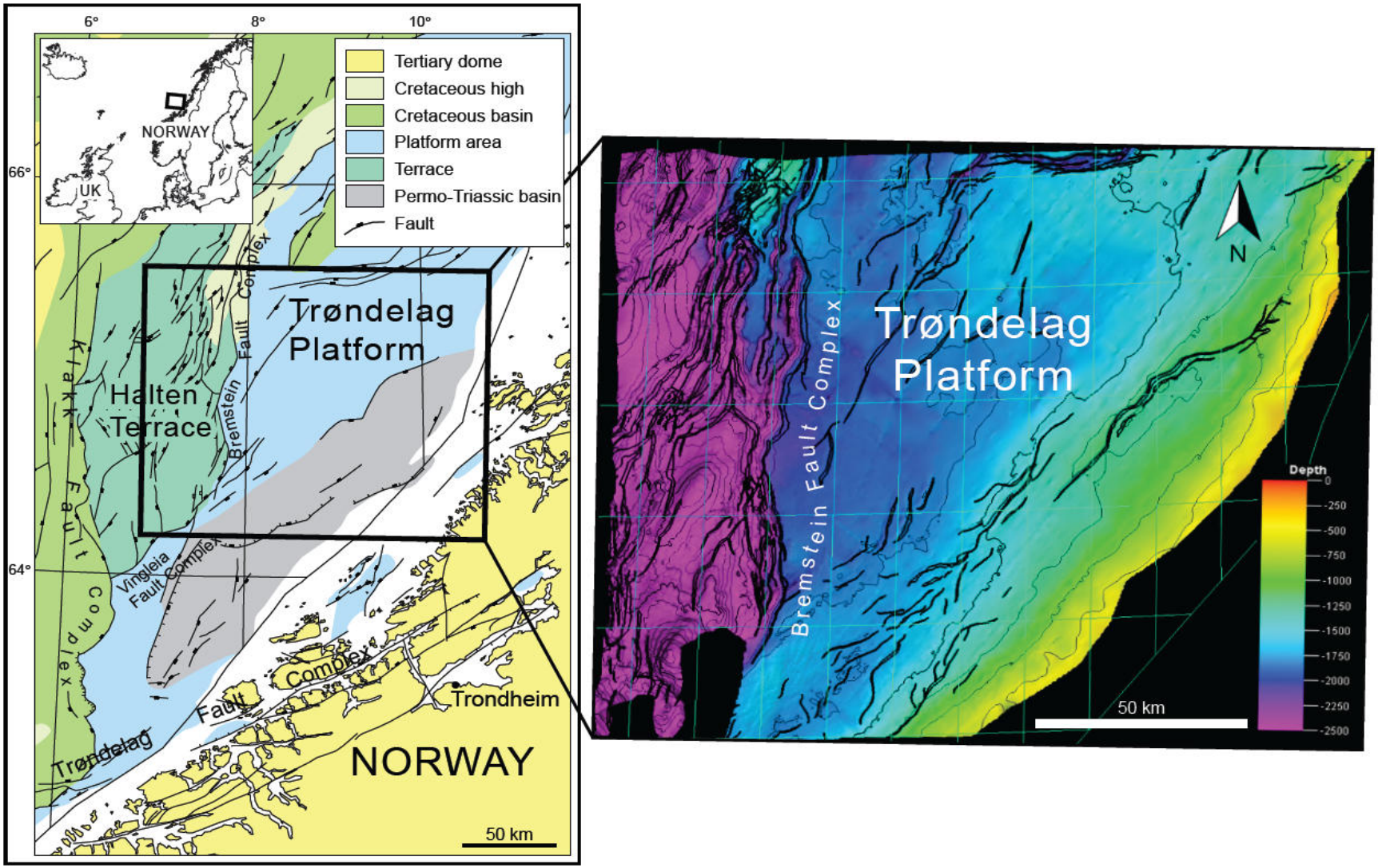
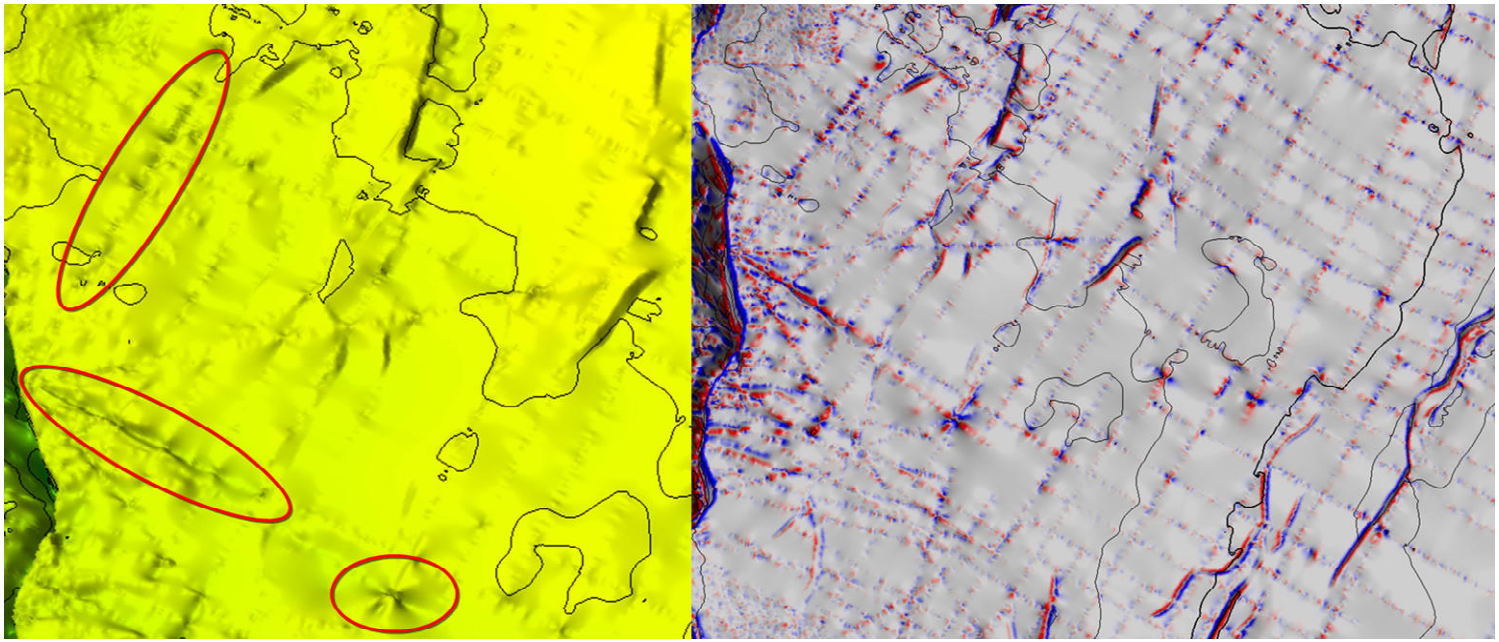
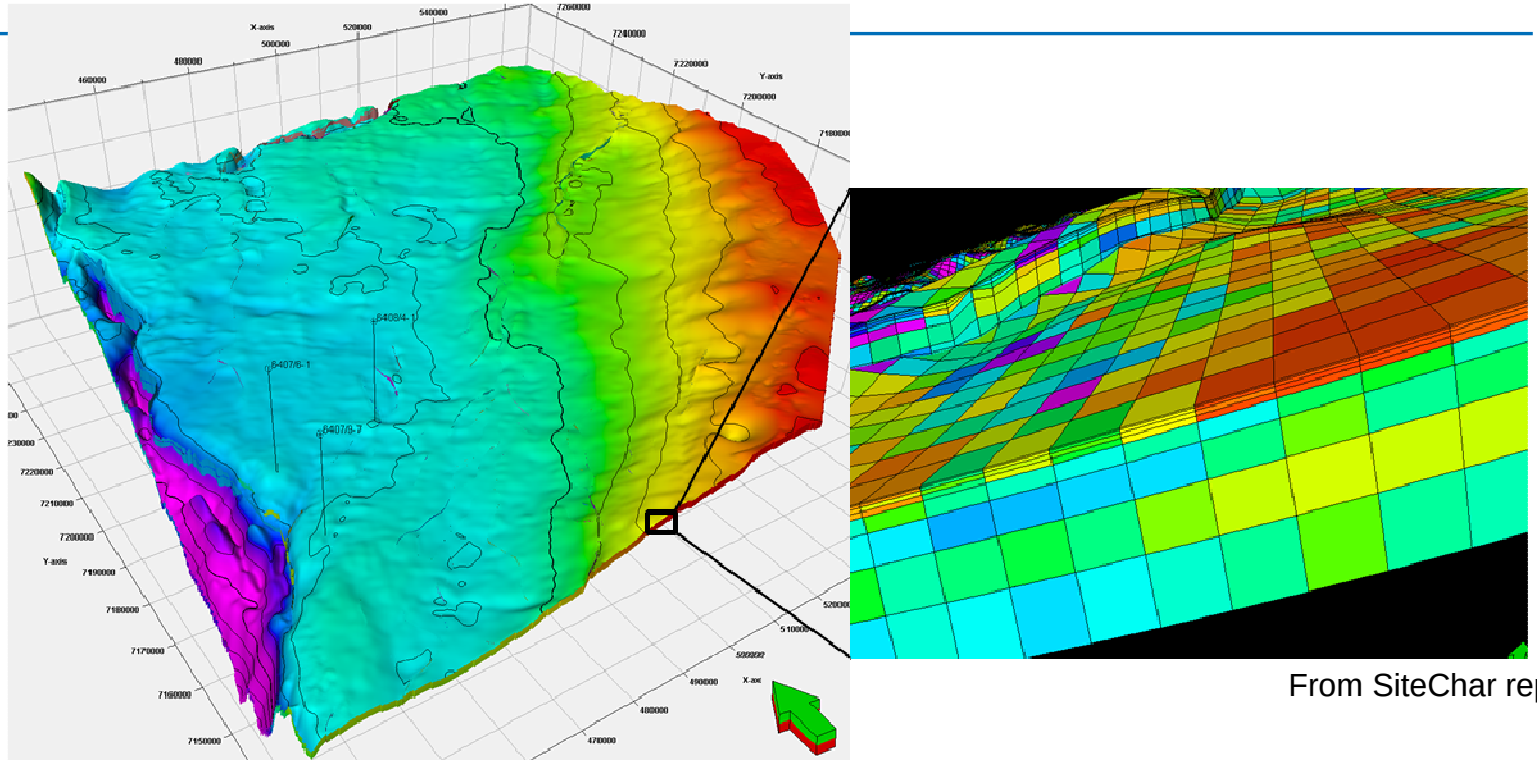
Study area – basin scale



Check the quality of the input data:



Examples of seismic miss-ties, interpretation miss-picks and data imprint



From SiteChar report (2013)

- In horizontal direction to 500 x 500 m grid cells.
- In vertical direction the layering was reduced to 8 layers
- The top layer is 1 m and thickness doubles each subsequent layer. This was done to ensure correct modelling of CO_2 gravity override. Total number of cells of the upscaled model is 240,000.

Modelling approaches

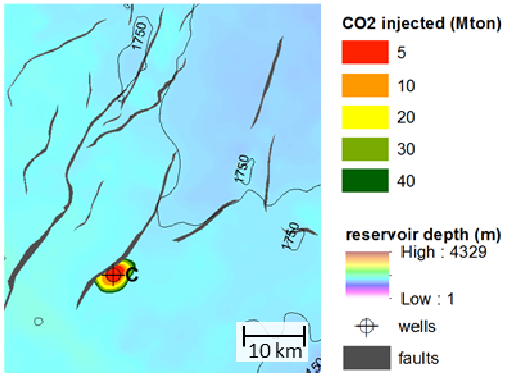
- Injection scenarios
  - Porosity/permeability based on well and literature data
  - Reservoir depth and pressure based on literature data
  - 3 injection sites (A, B and C)
  - Injection volume 1 Mt/a (low injection) and 5 Mt/a (high injection scenario)
  - No water producing well
- Modelling tools
  - Migration modelling using PetroCharge Express® (PetroMod)
  - Migration modelling using SINTEFs migration tool SEMI

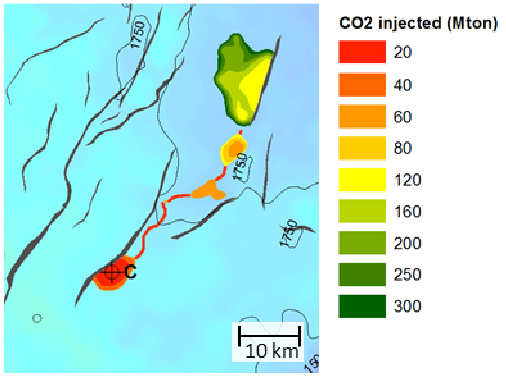
    with implemented loss functions for residual and density induced convention within the trap entities
  - Pressure modelling using Eclipse®

Task 6.2: Migration and leakage on basin scale - results achieved with Petromod-

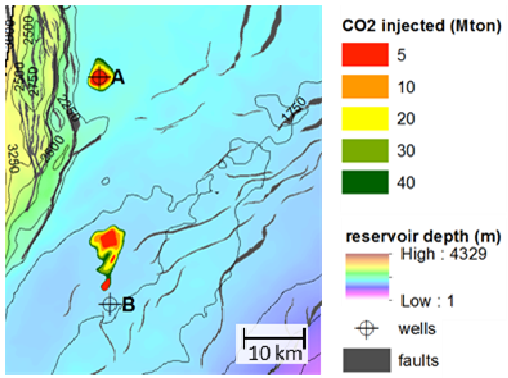
- Reservoir quality is very good, low compaction, high permeability (2-5 D).
- For the low injection volume scenario (1 Mt/a over 40 years) the injected CO_2 does not escape the injection sites.

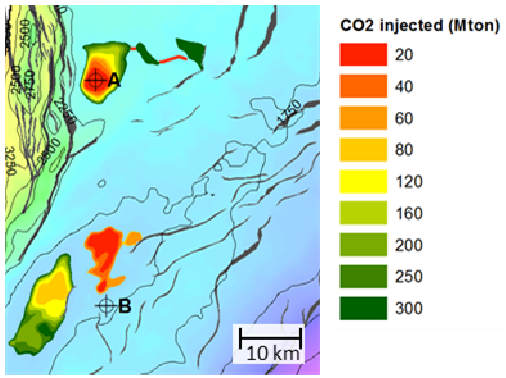
Injection site C (North Trøndelag Platform)





Injection sites A + B (SW Trøndelag Platform)

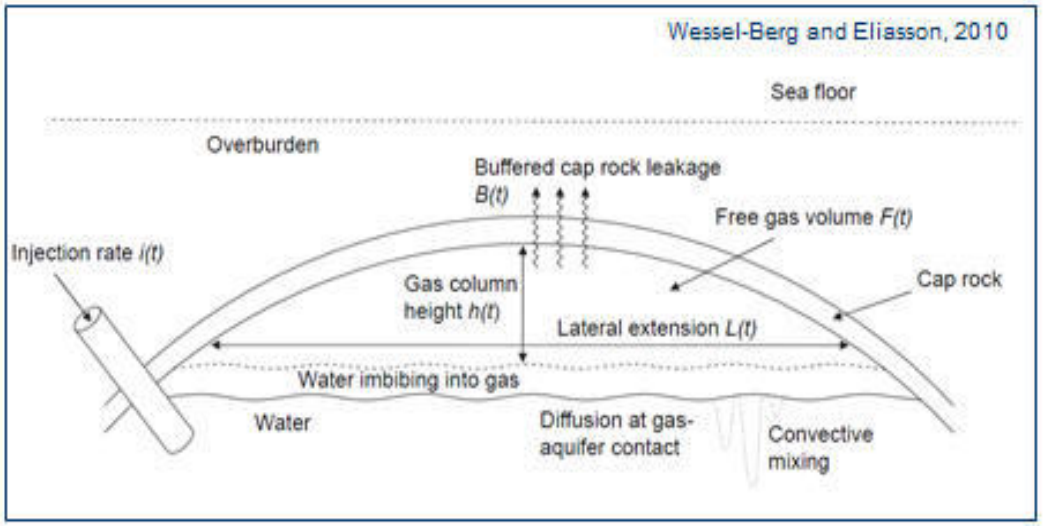




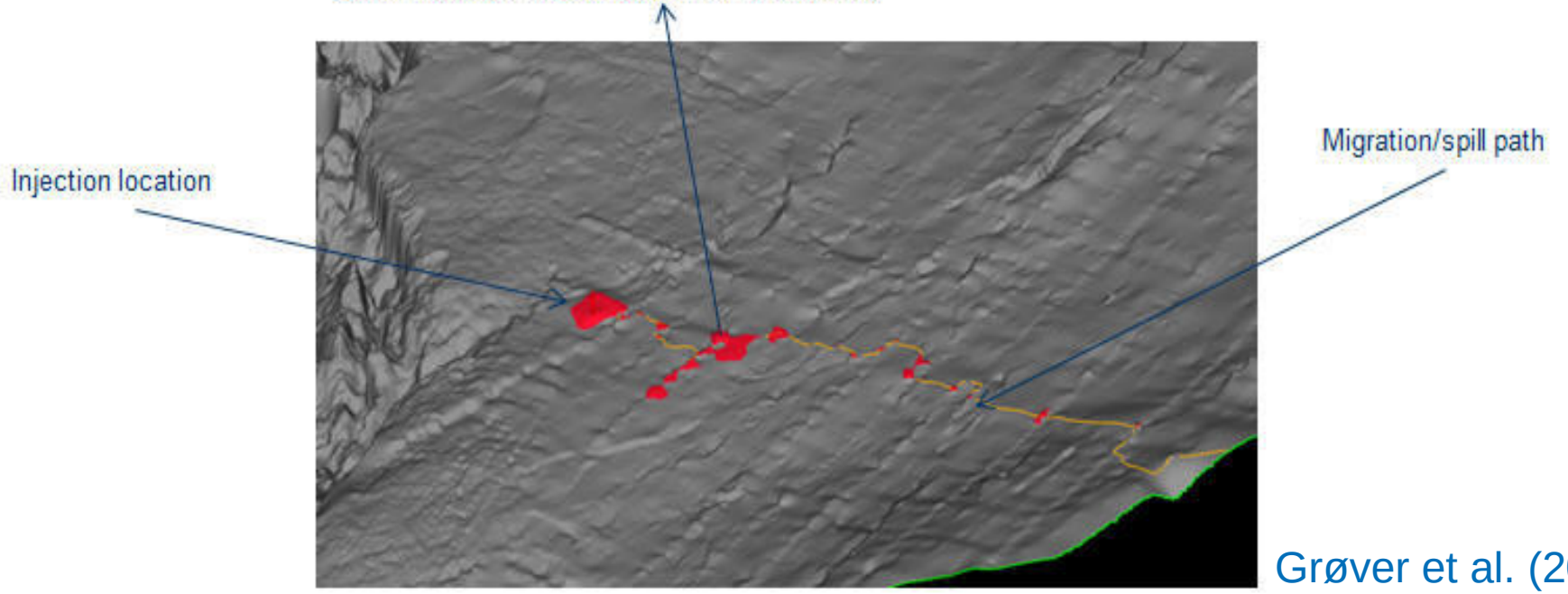
Low injection volume scenario

High injection volume scenario

From SiteChar report (2013)



Schematic view of CO2 loss within a trap entity

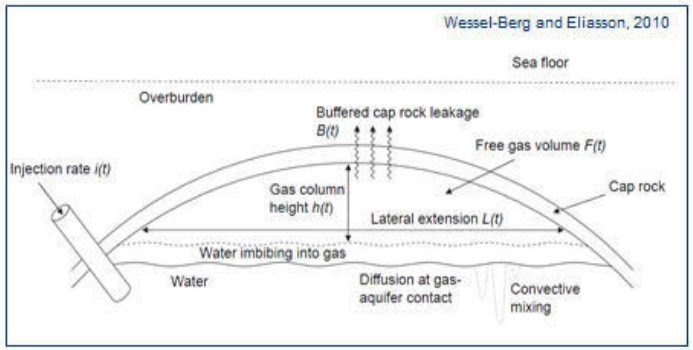


Grøver et al. (2013)

CO_2 dissolution within a trap entity (above), in context of a CO_2 storage simulation by basin modelling approach (below).

Task 6.2: Migration and leakage on basin scale - results achieved with SEMI -

- Loss functions have been introduced.



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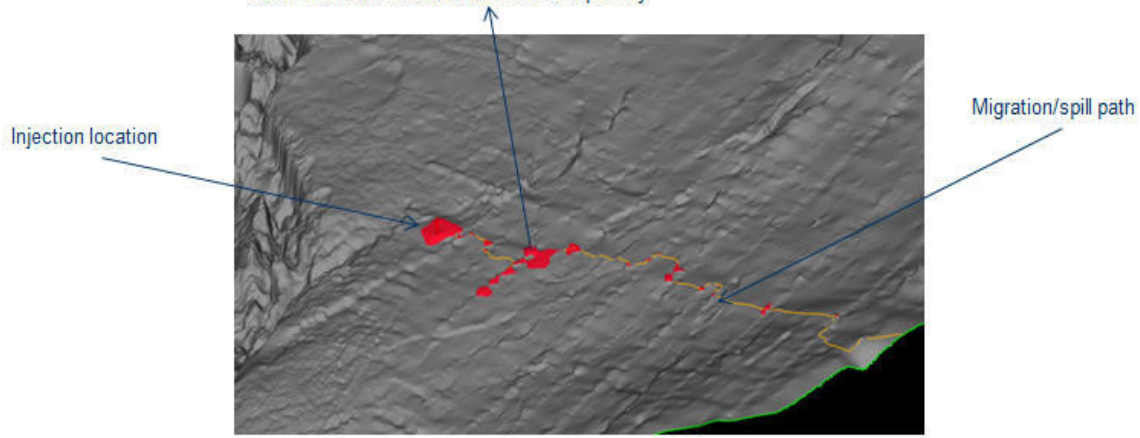
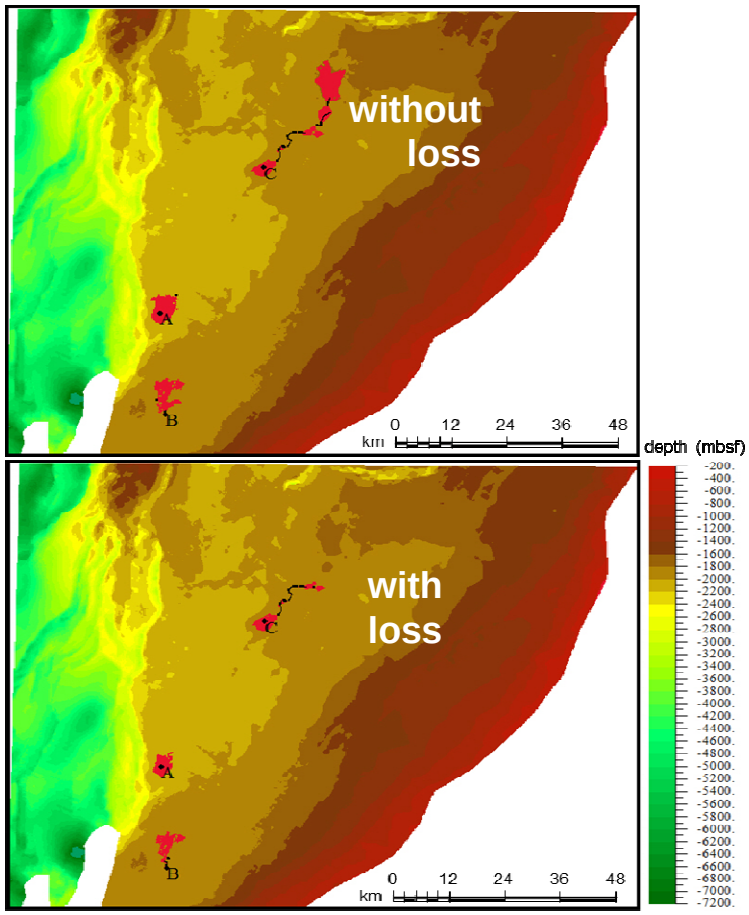


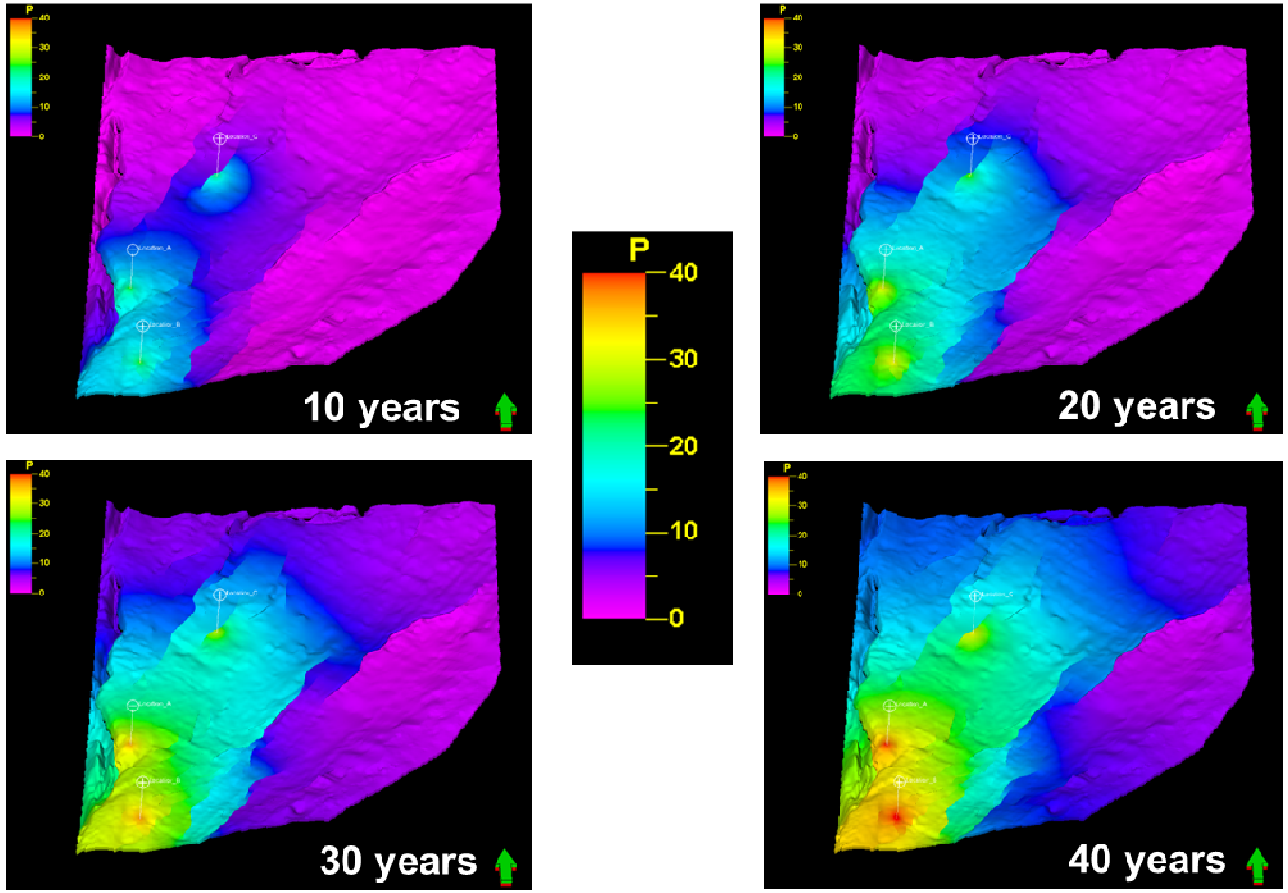
ICO_2 dissolution within a trap entity (above), in context of a CO_2 storage simulation by basin modelling approach (below).



2.2 Mt/a over 100 years, 400 years after start of injection

Task 6.2: Migration and leakage on basin scale - pressure constrains using Eclipse -

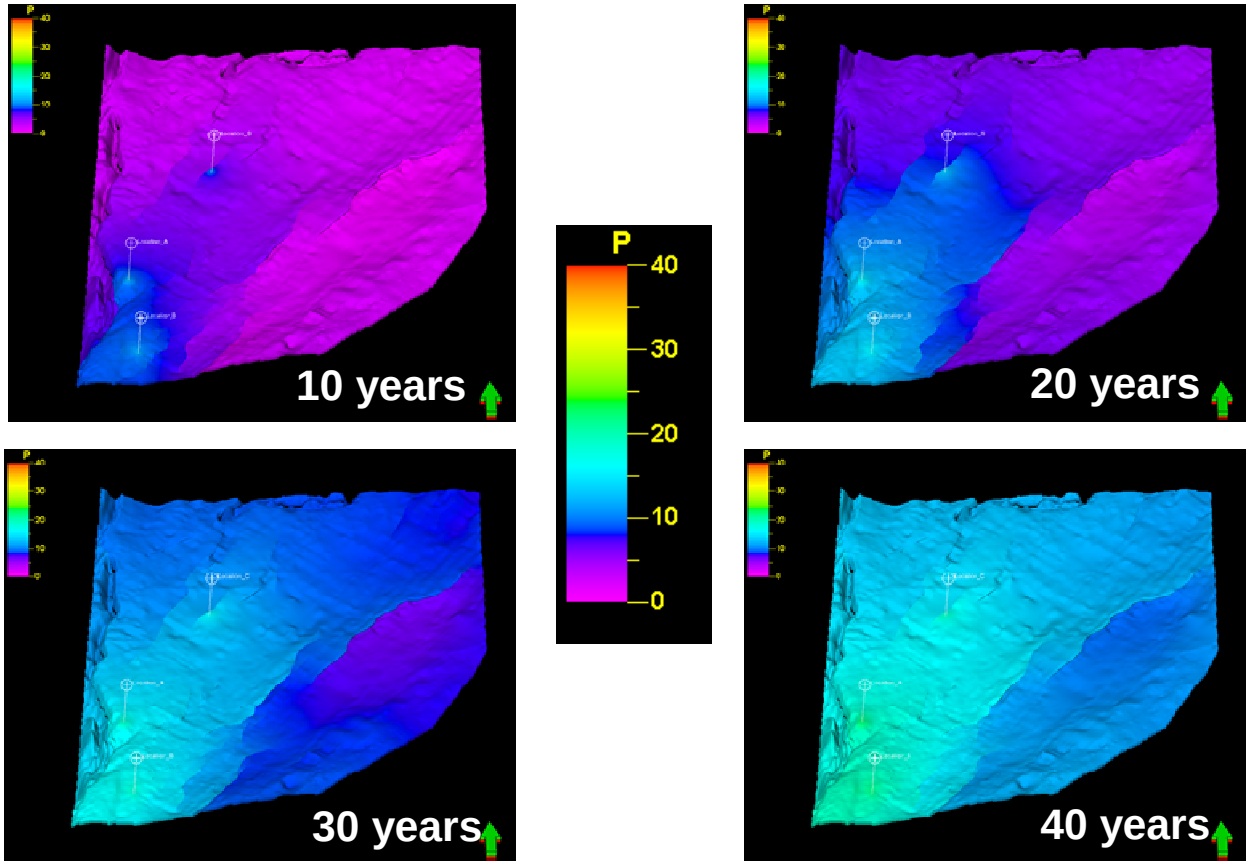
- Pressure increase at Fm. permeability of **500 mD**.
- CO_2 is injected at a rate of 5 Mt/year per well for a period of 40 years.



From SiteChar report (2013)

Task 6.2: Migration and leakage on basin scale - pressure constrains using Eclipse -

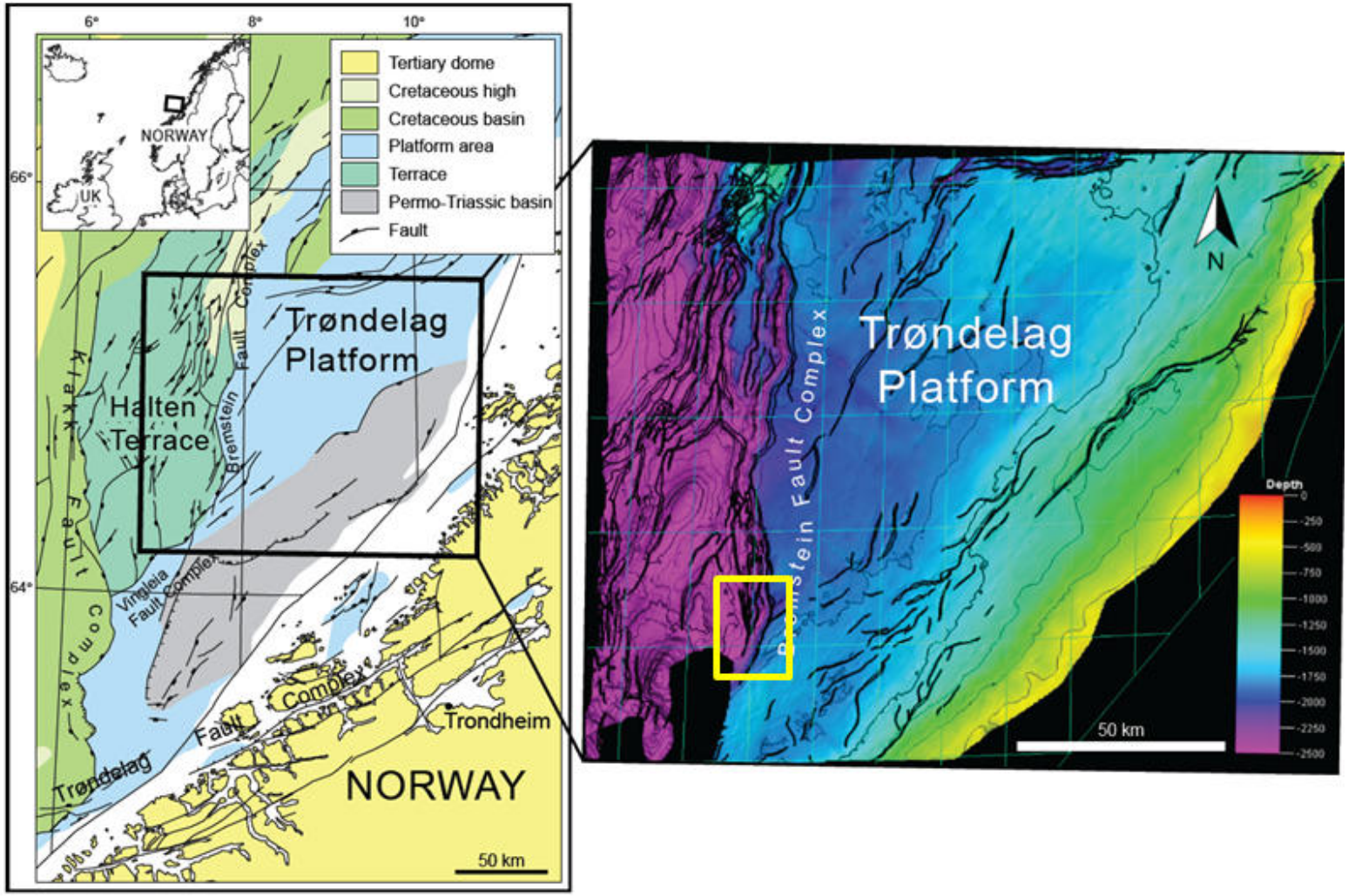
- Pressure build-up is not critical.
  - Pressure increase at Fm. permeability of **2000 mD**.
  - CO_2 is injected at a rate of 5 Mt/year per well for a period of 40 years.



From SiteChar report (2013)

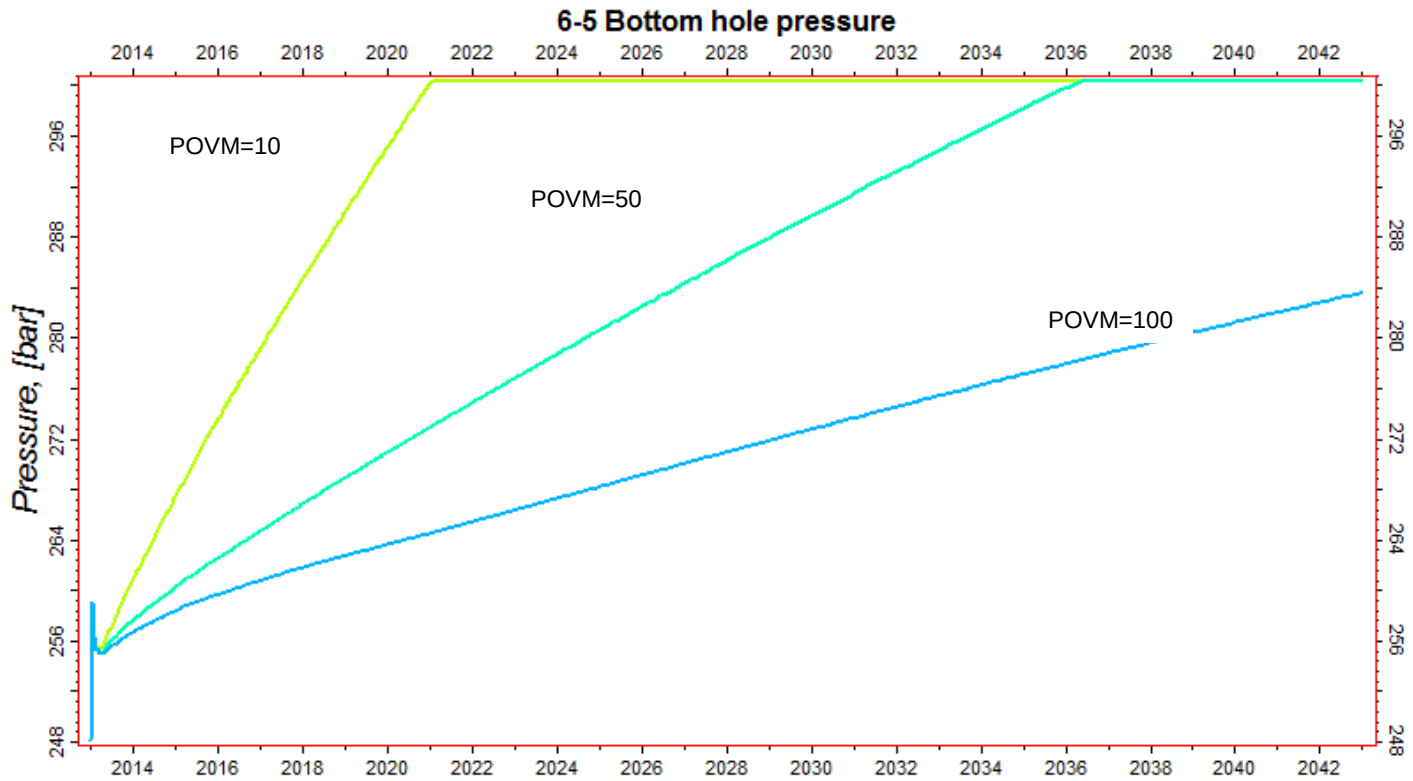
Smaller area

- **Challenge: what shall be used as the frame for the model?**

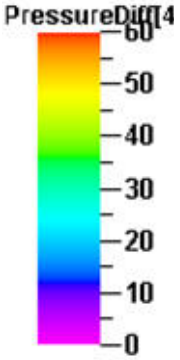

6°
8°
10°
66°
64°
NORWAY
UK
Tertiary dome
Cretaceous high
Cretaceous basin
Platform area
Terrace
Permo-Triassic basin
Fault
Trøndelag Platform
Halten Terrace
Bremstein Fault Complex
Klakk Fault Complex
Vingleia Fault Complex
Trondheim
Trøndelag
NORWAY
50 km
N
Depth
0
-250
-500
-750
-1000
-1250
-1500
-1750
-2000
-2250
-2500

Task 6.3: BHP (Sealing Faults, 4 Mt/year)

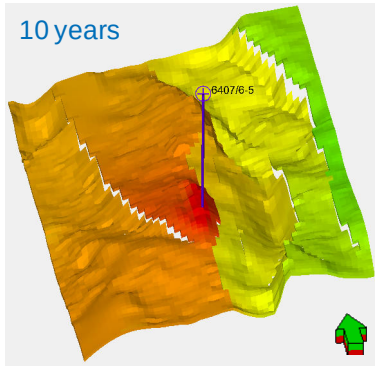
- **A pore volume multiplier (between 10 and 100) was used.**
- **The injection rate could be maintained for only 8 and 23 years for POVM = 10 and 50, respectively.**

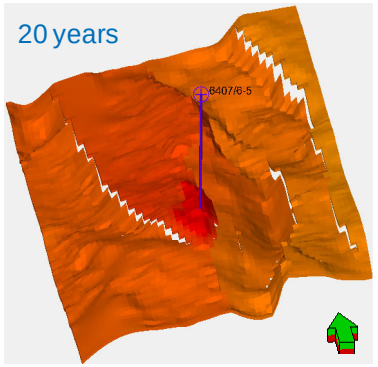


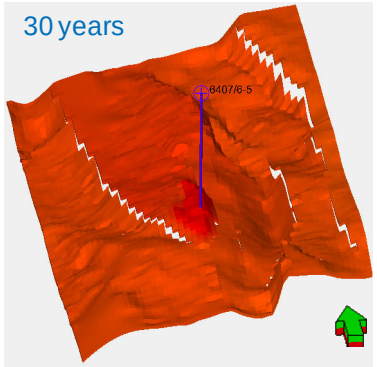
Task 6.3: Reservoir pressure increase, 4 Mt/a (sealing faults) (IMPERIAL)



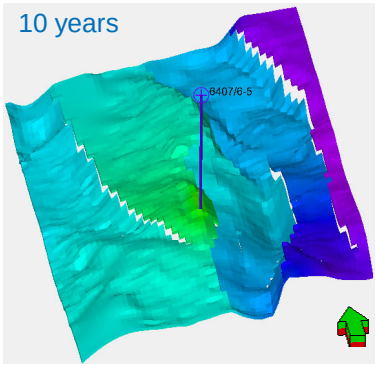
POVM= 10

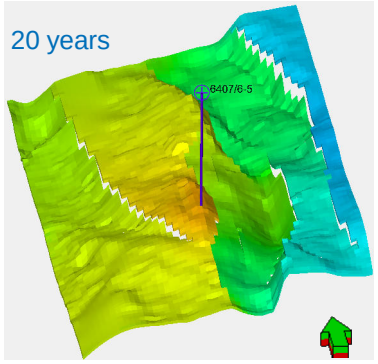


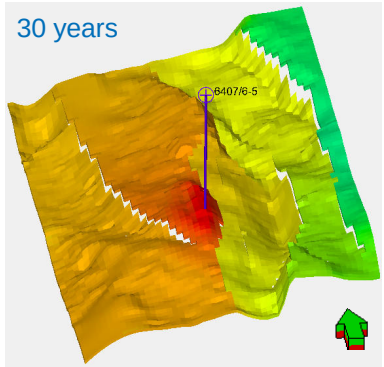




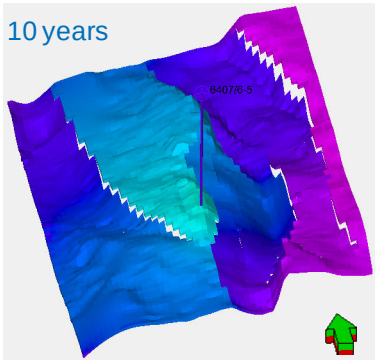
POVM = 50

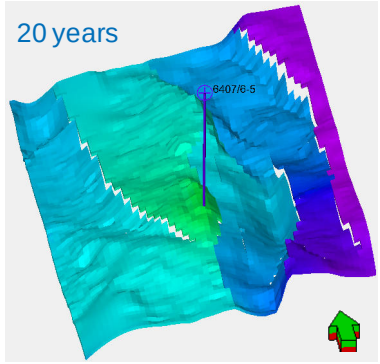


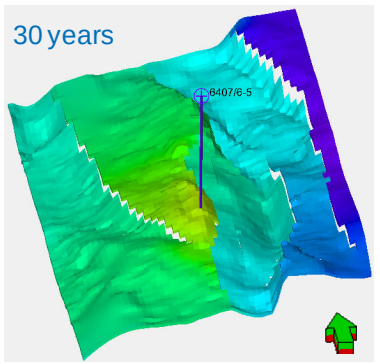




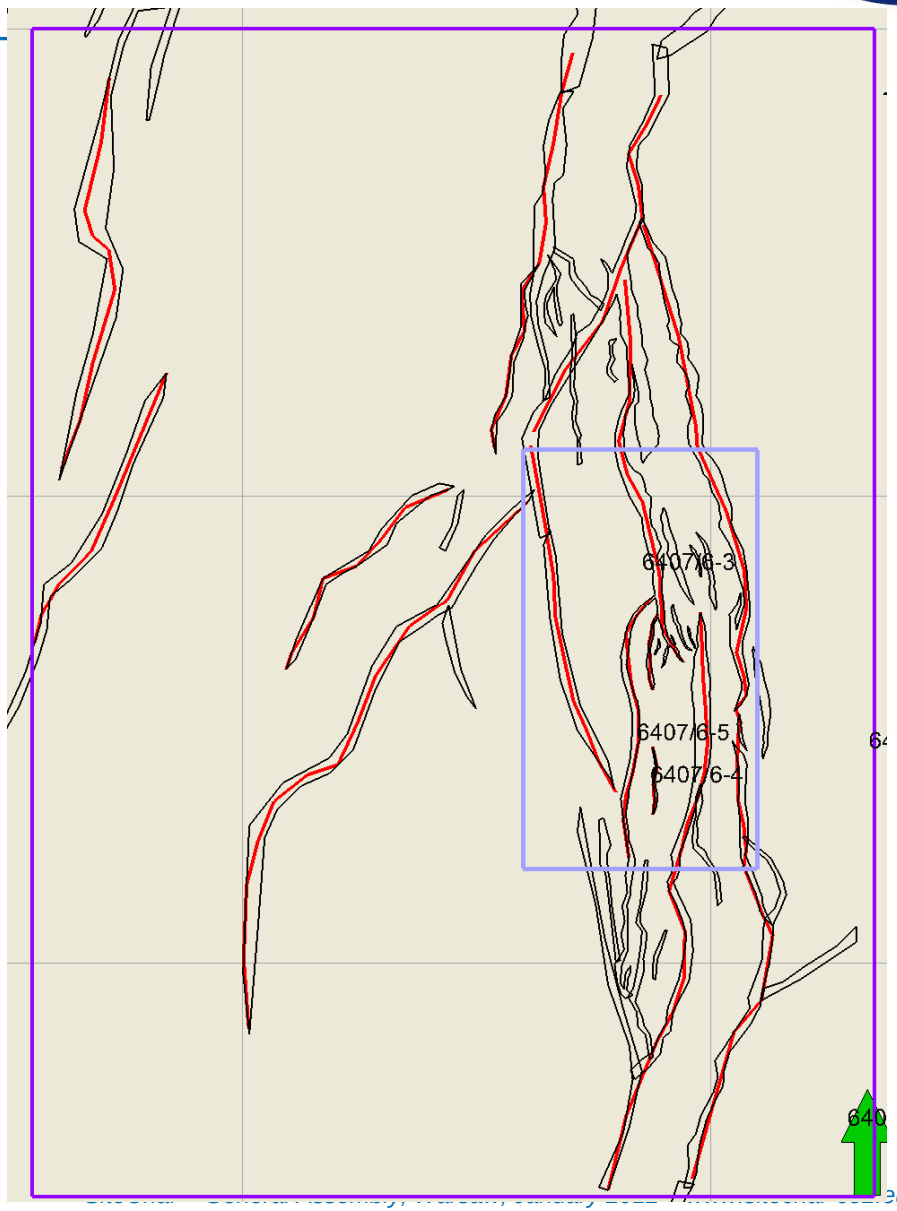
POVM = 100

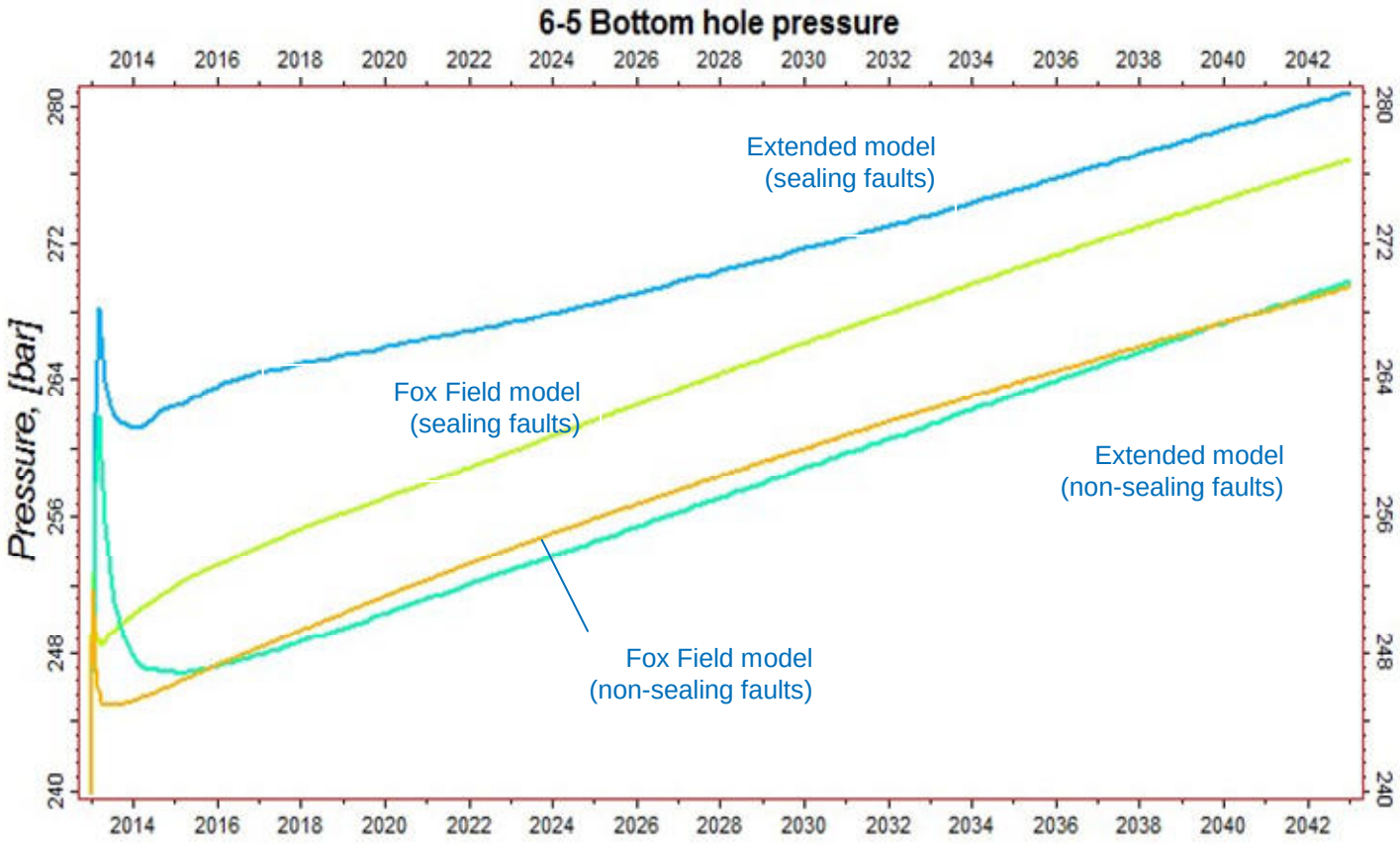






Increase the study area

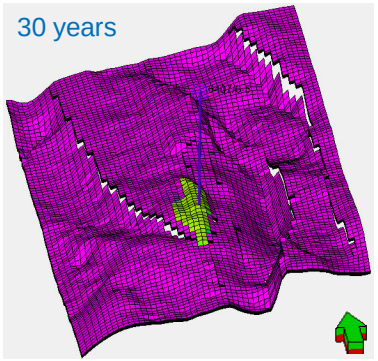




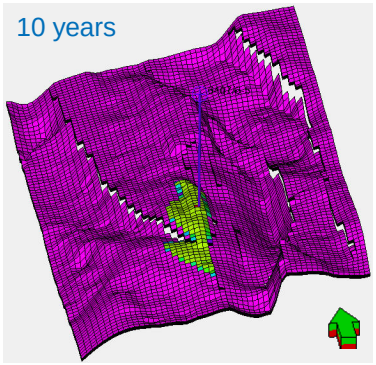
Simulated injection well BHP: Extended model vs. Fox Field Model (POVM=100)

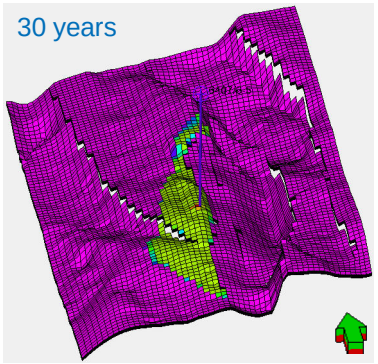
Task 6.3: CO_2 plume development (sealing faults) (IMPERIAL)

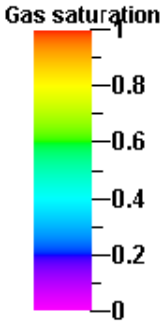
1 Mt/a (POVM = 100)

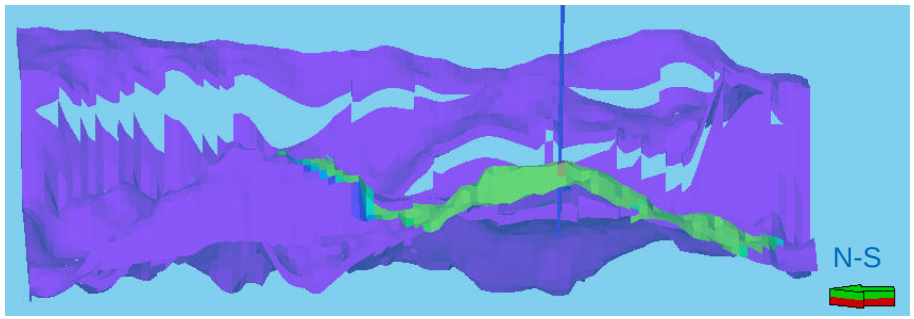


4 Mt/a (POVM = 100)

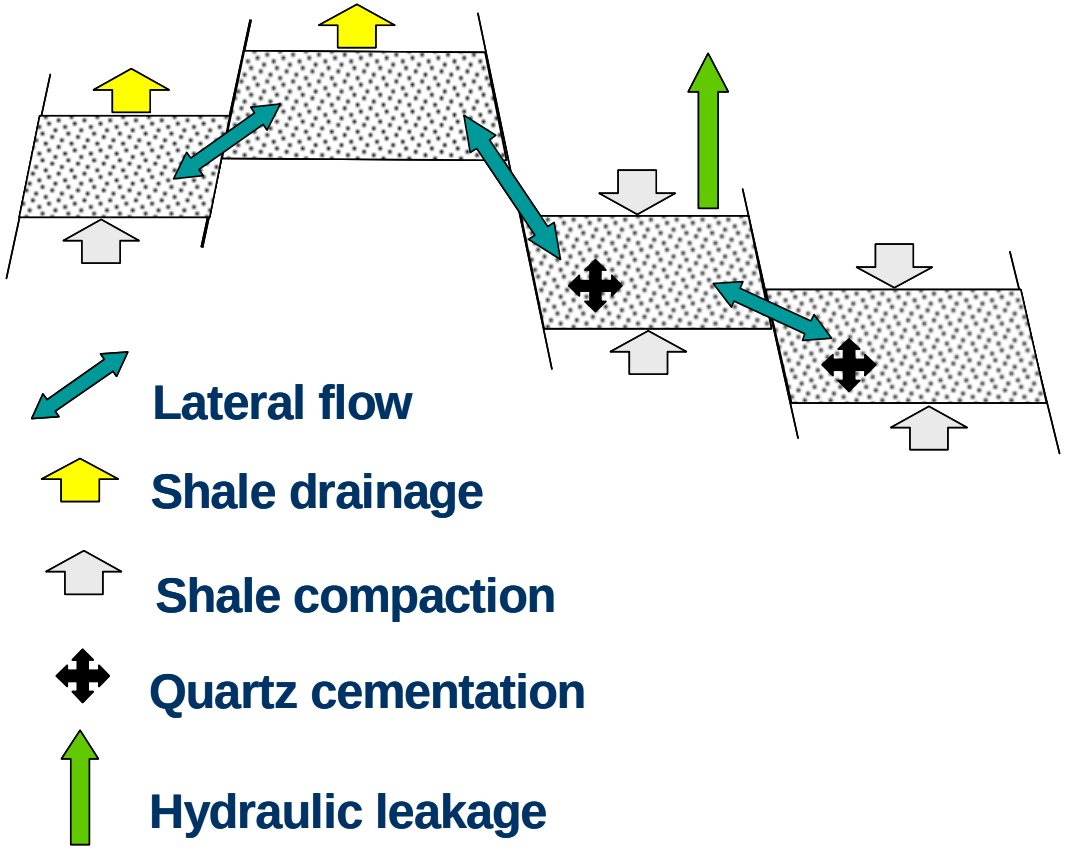






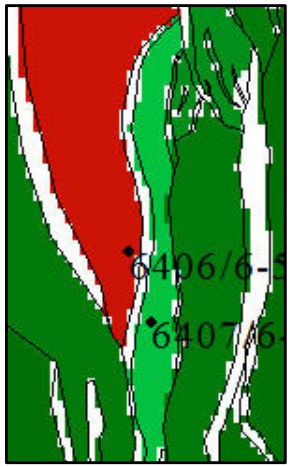


Pressim

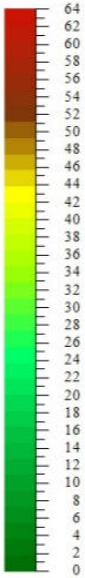

Lateral flow
Shale drainage
Shale compaction
Quartz cementation
Hydraulic leakage

Comparison of different simulations tools

a)

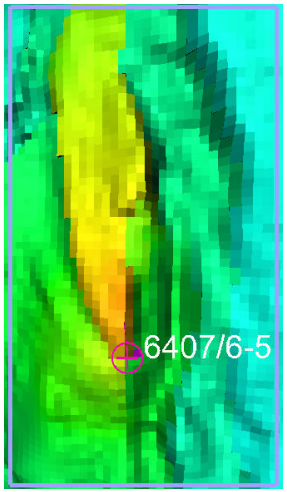


Large model (Pressim)



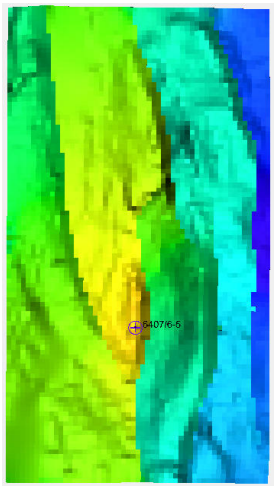
Over-pressure (bar)

b)

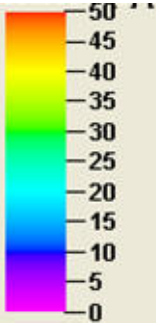


Extended model (Eclipse)

c)



Fox Field Model (Eclipse)



Overpressure bar

Conclusions

- The Trøndelag Platform is a relative large basin with a number of potential storage structures
- Three different simulation tools and methods have been used to simulate the pressure build up with CO_2 injection in a potential storage formation.
- Pressim and Eclipse, we see that the overall pressure patterns are more or less the same, and also the amount
- Pressure build-up, even under high injection rates are low to moderate
- The pore volume multiplier is important – PVMP=100, gives good results