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Geomechanical Risk Assessment Using Field Scale Geomechanics 3D Model: Case Study on Smeaheia CO2 Storage Site

18.June.2019

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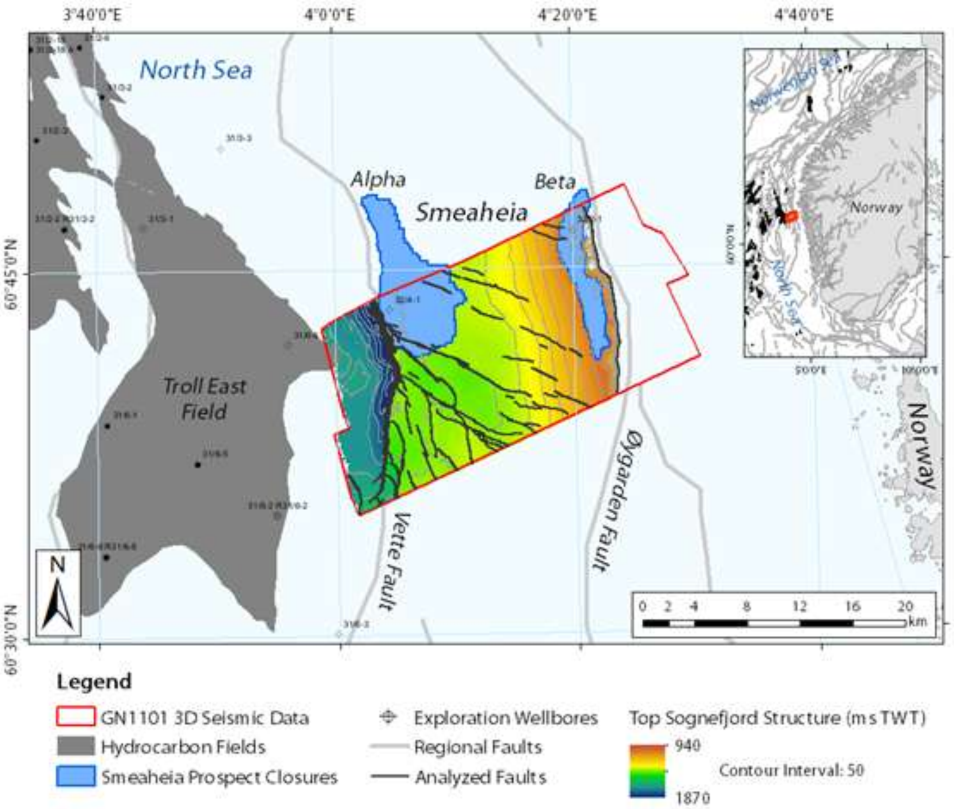
10th Conference
Trondheim CCS Conference
CO_2 Capture, Transport and Storage

Smeaheia CO2 storage site



- Located at Horda Platform East of Troll field
- High porous saline aquifer reservoir at the depth of 1200-1500 m below sea level
- Two large storage structures Alpha and Beta, which has CO_2 storage capacity of 100 Mt each

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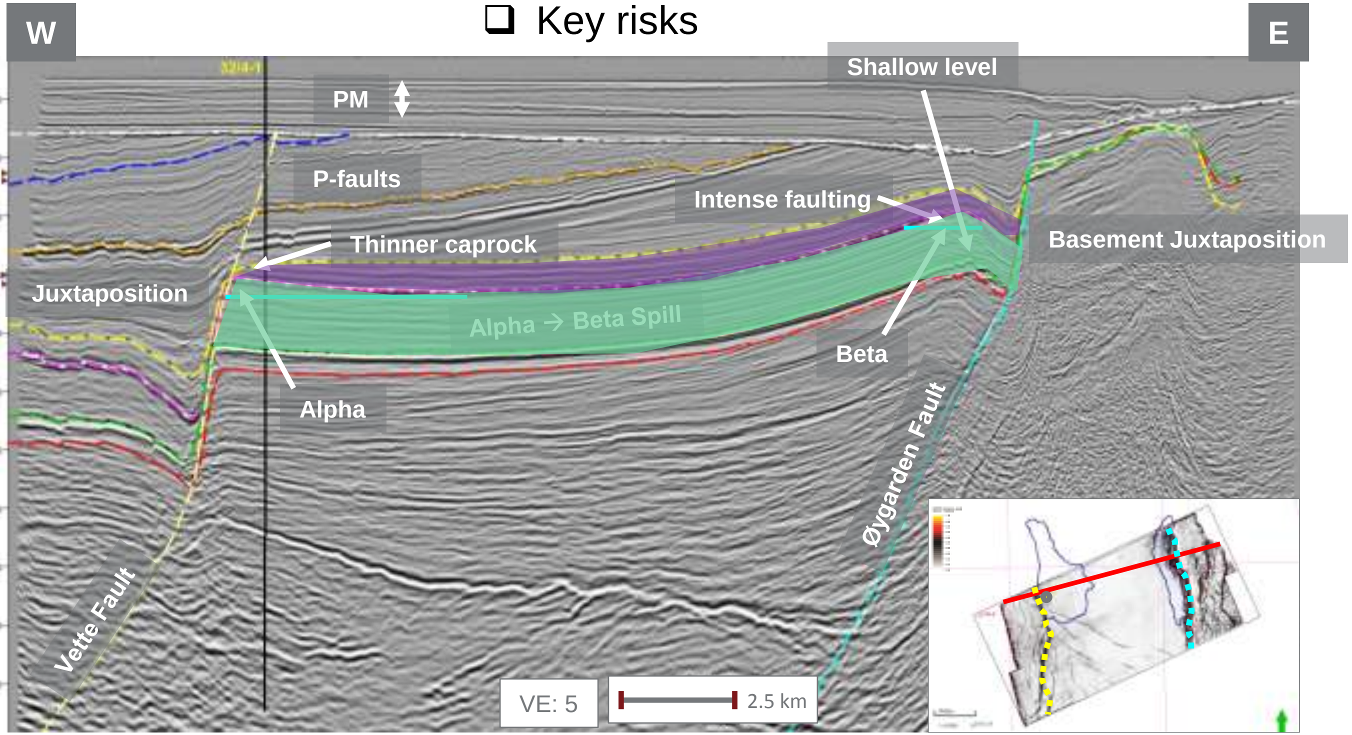
(Equinor, 2016)

Geomechanics risk on Smeaheia



Mulrooney et al., 2018

- Reactivation of Vette and Øygarden faults
- Caprock integrity
- Seabed heave and Associated geohazard

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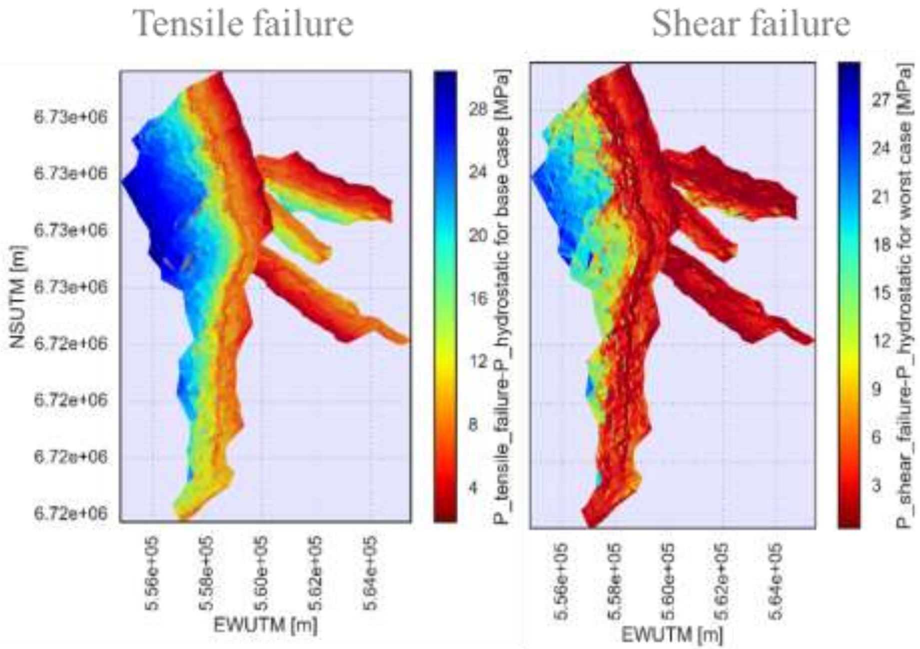
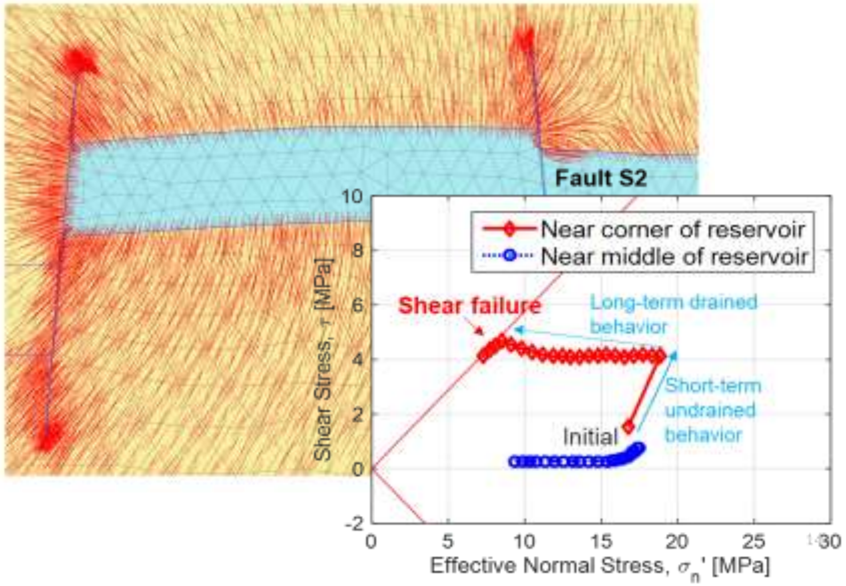
Previous study on derisking CO2 storage sites

Fault stability for Smeaheia area



Skurtveit et al., 2018

2D geomechanics model for Snøhvit



Choi et al., 2015

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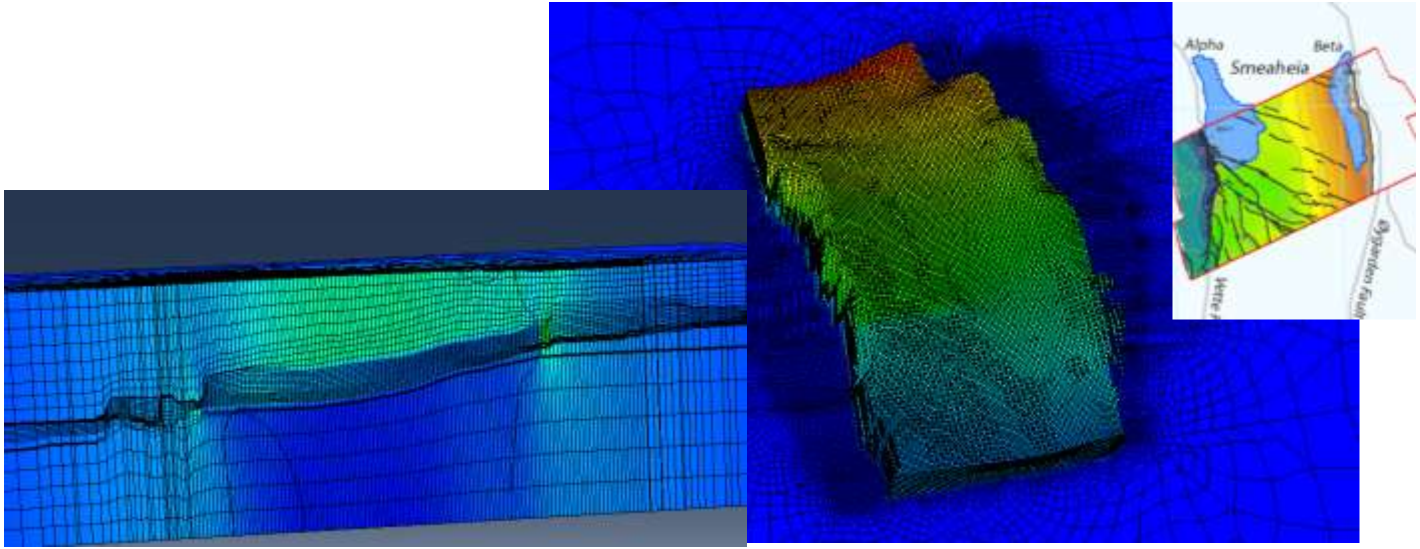
Objective and scope of work

- Aims to develop full 3D FE model for geomechanical stability analyses of reservoir at Smeaheia site
- improving understanding on the stress change and associated instability in caprock and faults in Smeaheia site



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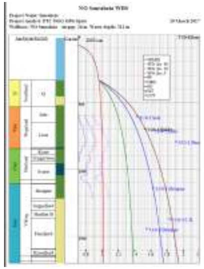
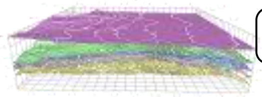
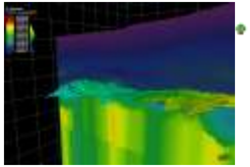
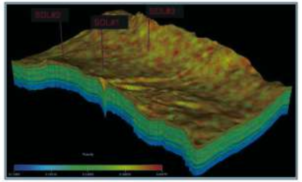
Modeling procedure

- NGI's in-house workflow that can build 3D geomechanics model by linking Eclipse, Geomodel and Abaqus is used









NGI in-house workflow
ResGeomechModeler

Geological model → Fault geometry → Model geometry and mesh

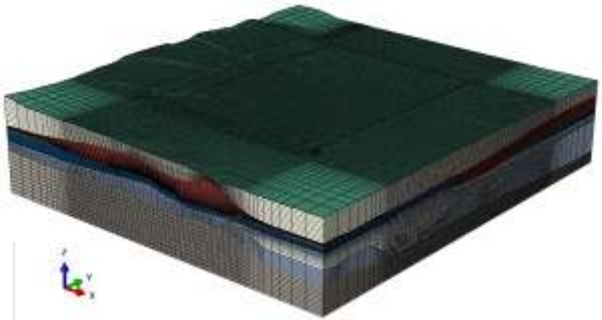
Geological model → Petrophysical data → Material properties assignment

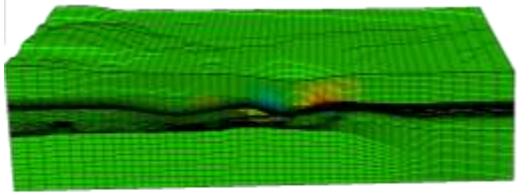
Lab-testing data → Geomechanical properties → Material properties assignment

Core, logs and direct measures → In-situ stress → Initial condition assignment

Reservoir model → Saturation, Pressure → Load history

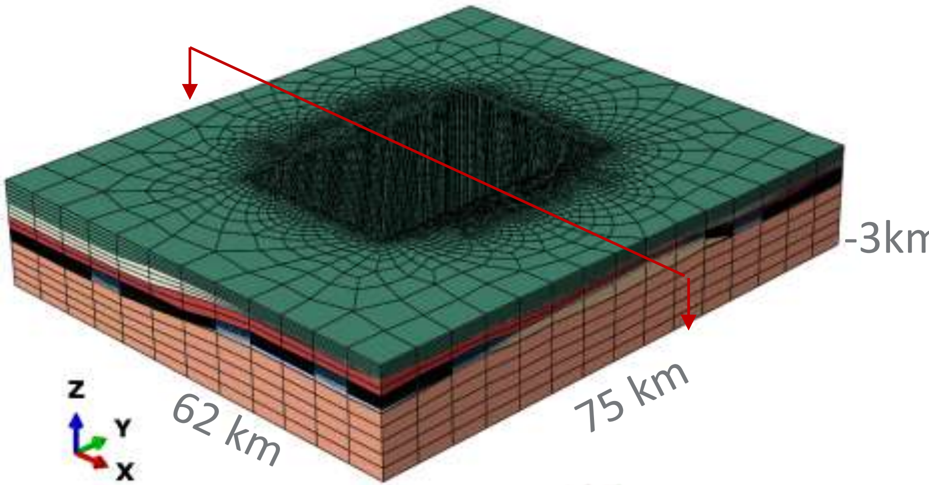
1. Model geometry and mesh
2. Material properties assignment
3. Initial condition assignment
4. Boundary condition assignment
5. Validation against data from wells
6. Load history
7. Analysis





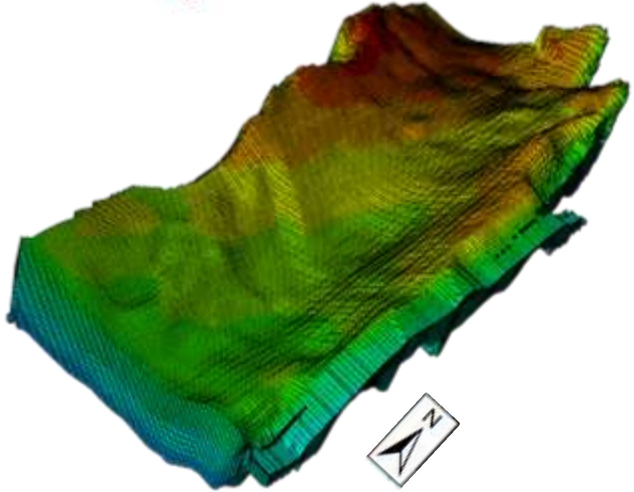
Geometry

- 9 Fm. or Gp. are included
- Number elements = 1.5 mil
- Element type: C3D8RP (8-node trilinear displacement and pore pressure, reduced integration)



Reservoir

Layer No.	Top of layer	Depth_mean	thickness
1	00_Seabed.txt	-301.5	513.8
2	01_Top Shetland Gp.txt	-815.3	255.86
3	02_Draupne Fm.txt	-1071.16	204.24
4	03_Sognefjord Fm.txt	-1275.4	162.1
5	04_Fensfjord Fm.txt	-1437.5	125.7
6	05_Brent Gp.txt	-1563.2	13.5
7	06_Dunlin Gp.txt	-1576.7	22.1
8	07_Johansen Fm.txt	-1598.8	25.5
9	08_Top Statfjord Fm.txt	-1624.3	1375.7
	Bottom of the model	-3000	



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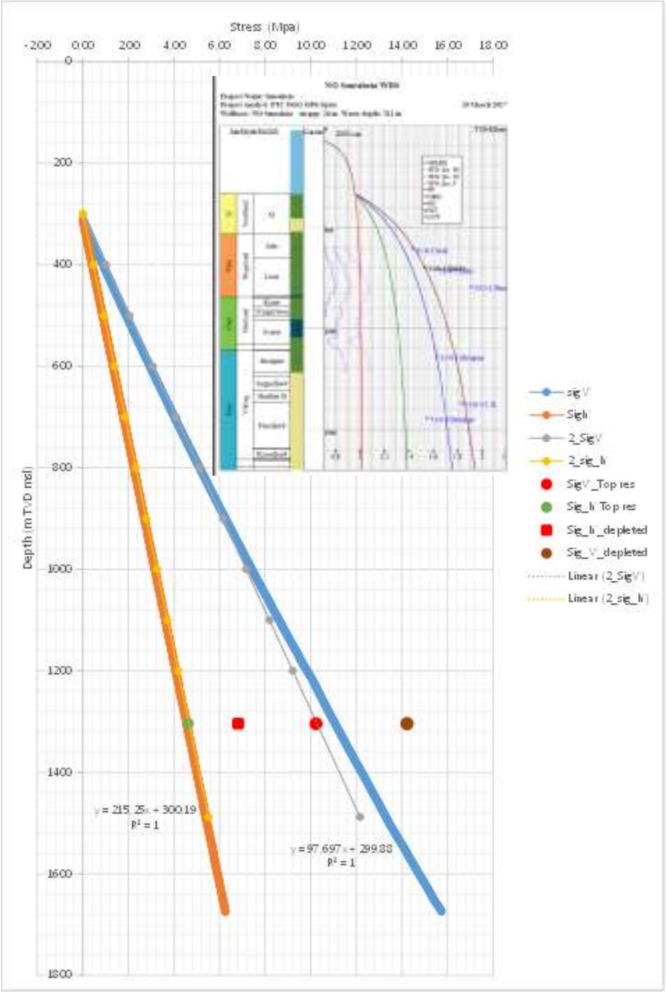
Stress condition

- Data from Northern Lights data package

  - K0 = 0.45
  - Gamma_v_eff = 10.235 kPa/m from seabed
  - Hydrostatic_pp_gradient = 9.905 – 10.069kPa/m



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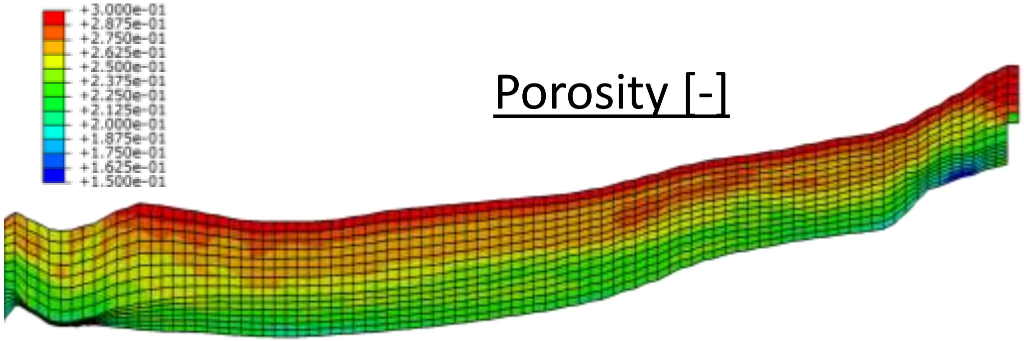
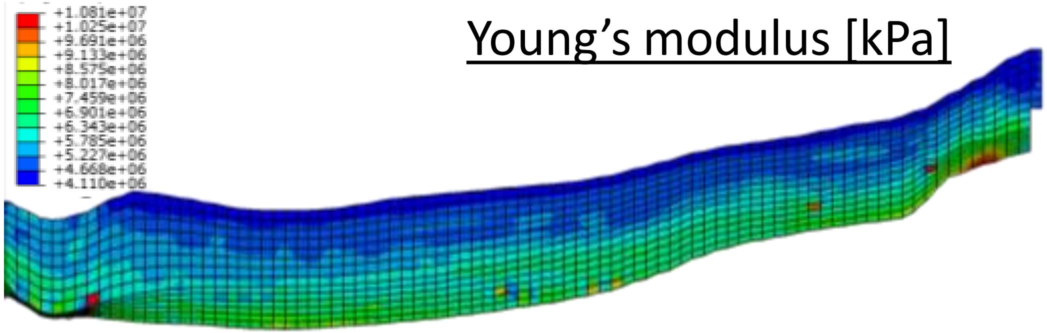
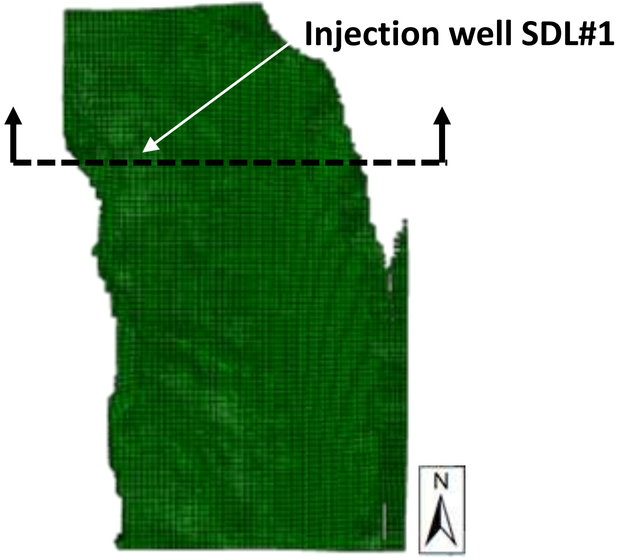
Material input

- Data package from Northern Lights project and interal NGI database are used.
- Porosity dependent material properties are used for the reservoir

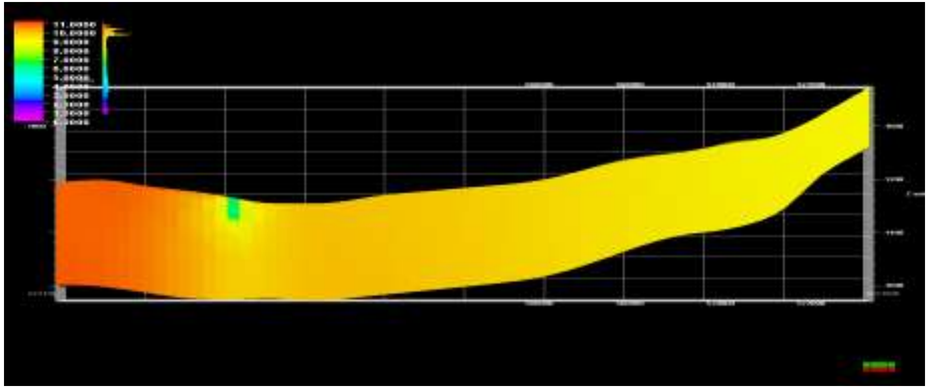






Reservoir pressure

- Reservoir simultion from Equinor 2016 feasibility study (Statoil, 2016) are used as a basis.
- Injection of 1.3 MT CO2/yr during 25yrs (total injection of 32.MT CO2) is considered for the model.
- The injection well is considered as SDL#2, which is in Alpha structure.
- At 2045, the pressure build up near injector is around 11 bar



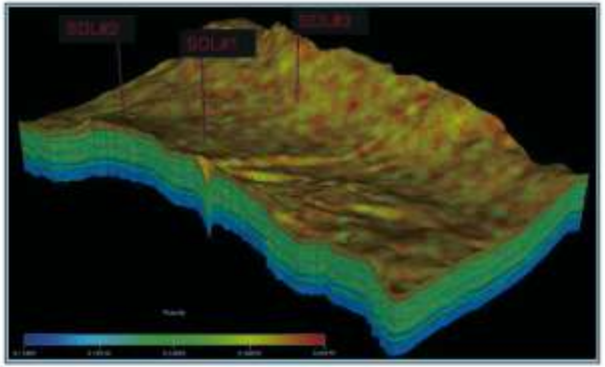
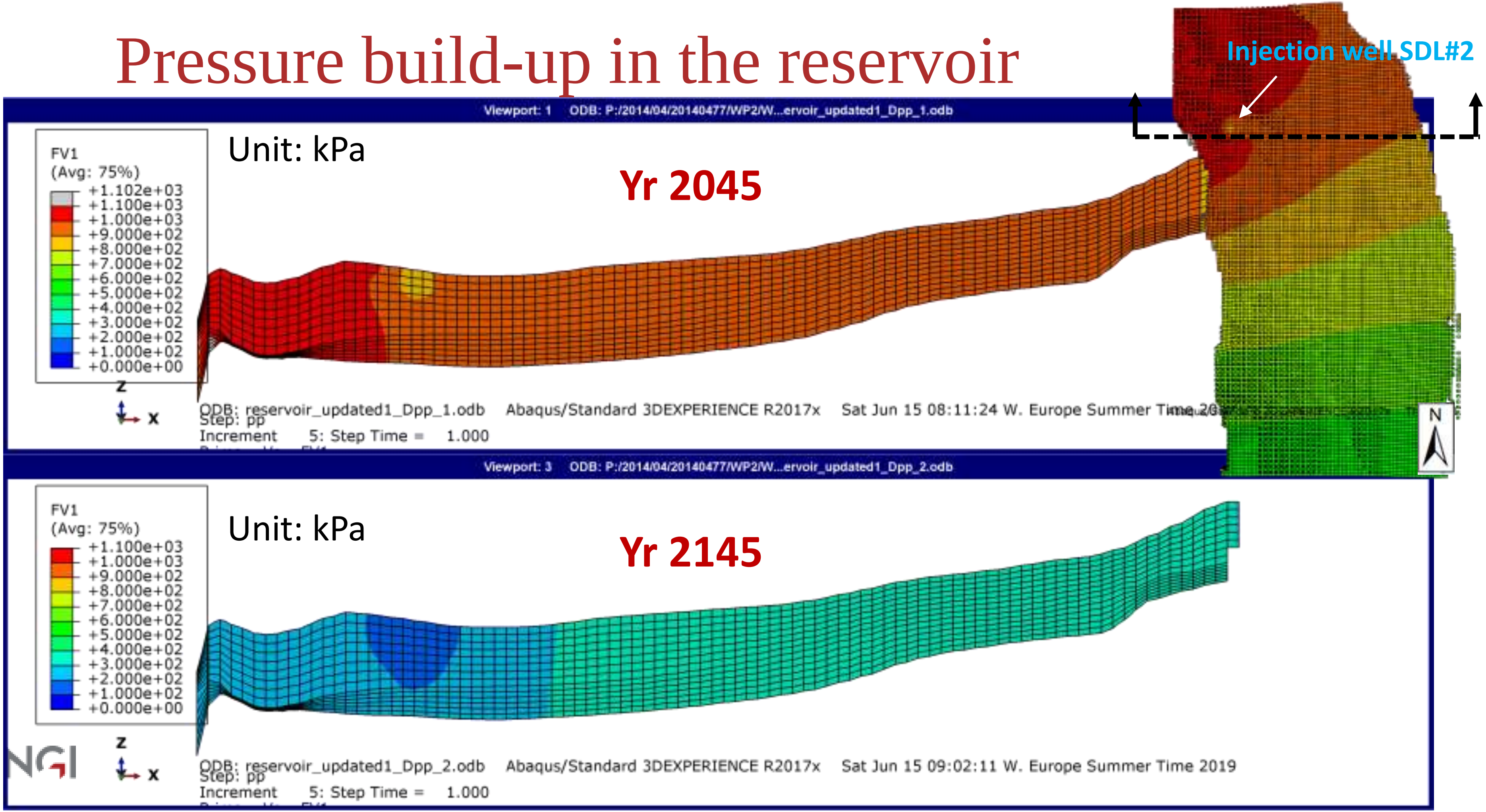


Figure 9-1: Porosity map and location of three proposed well locations for Smeaheia reservoir.

Pressure build-up in the reservoir



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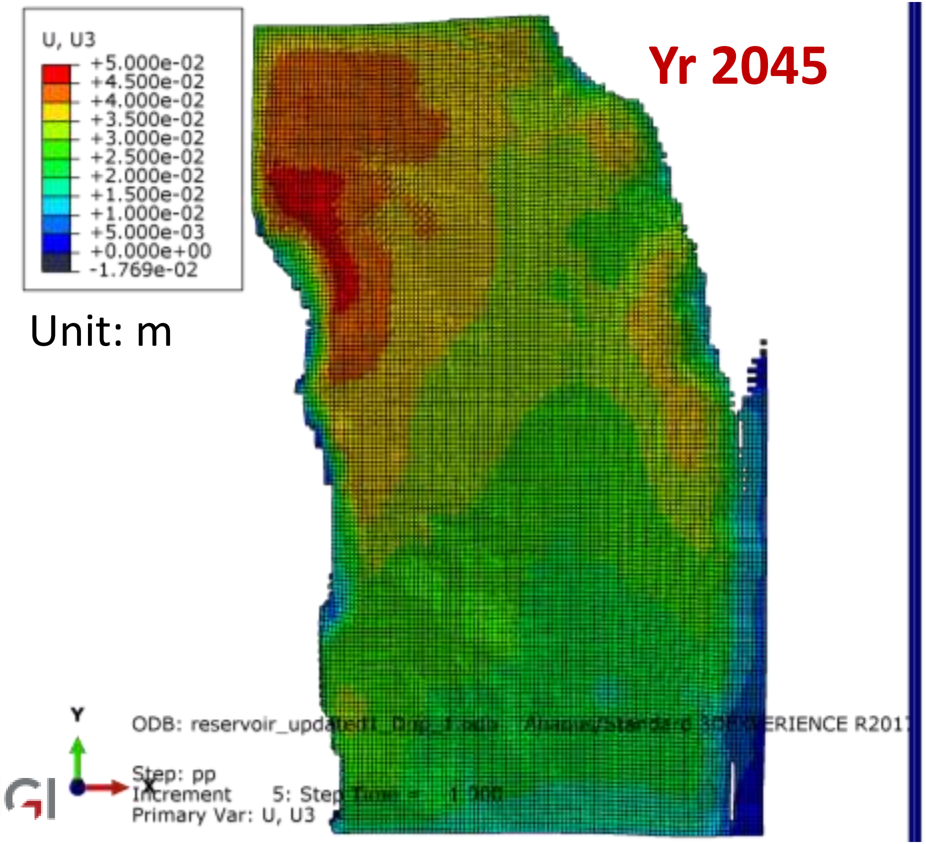
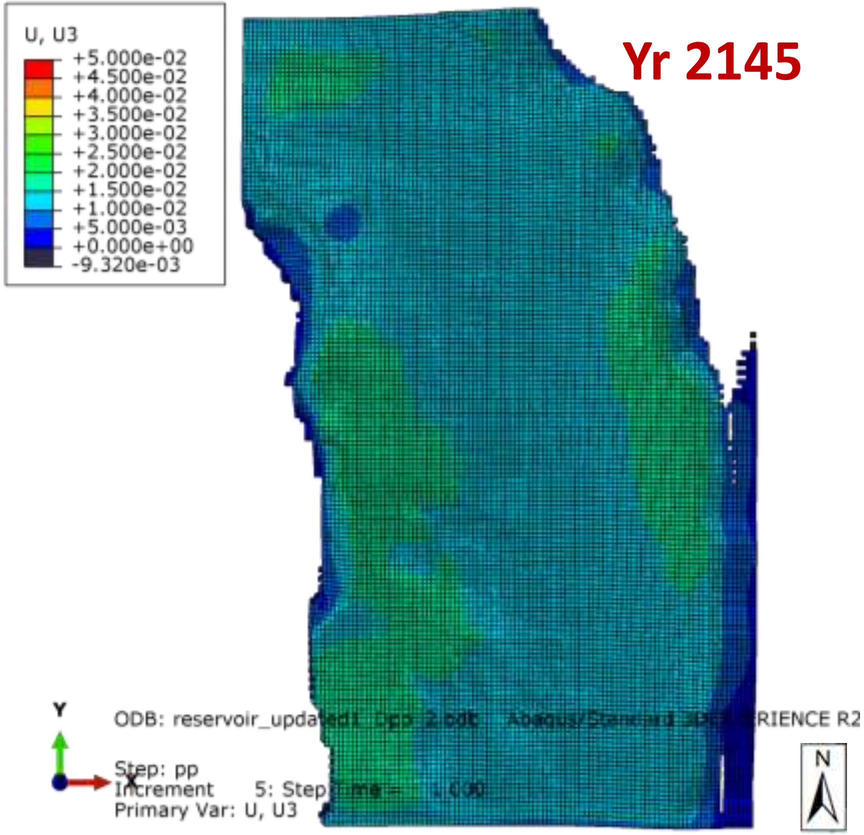
Vertical deformation in reservoir

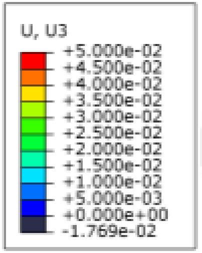


Unit: m

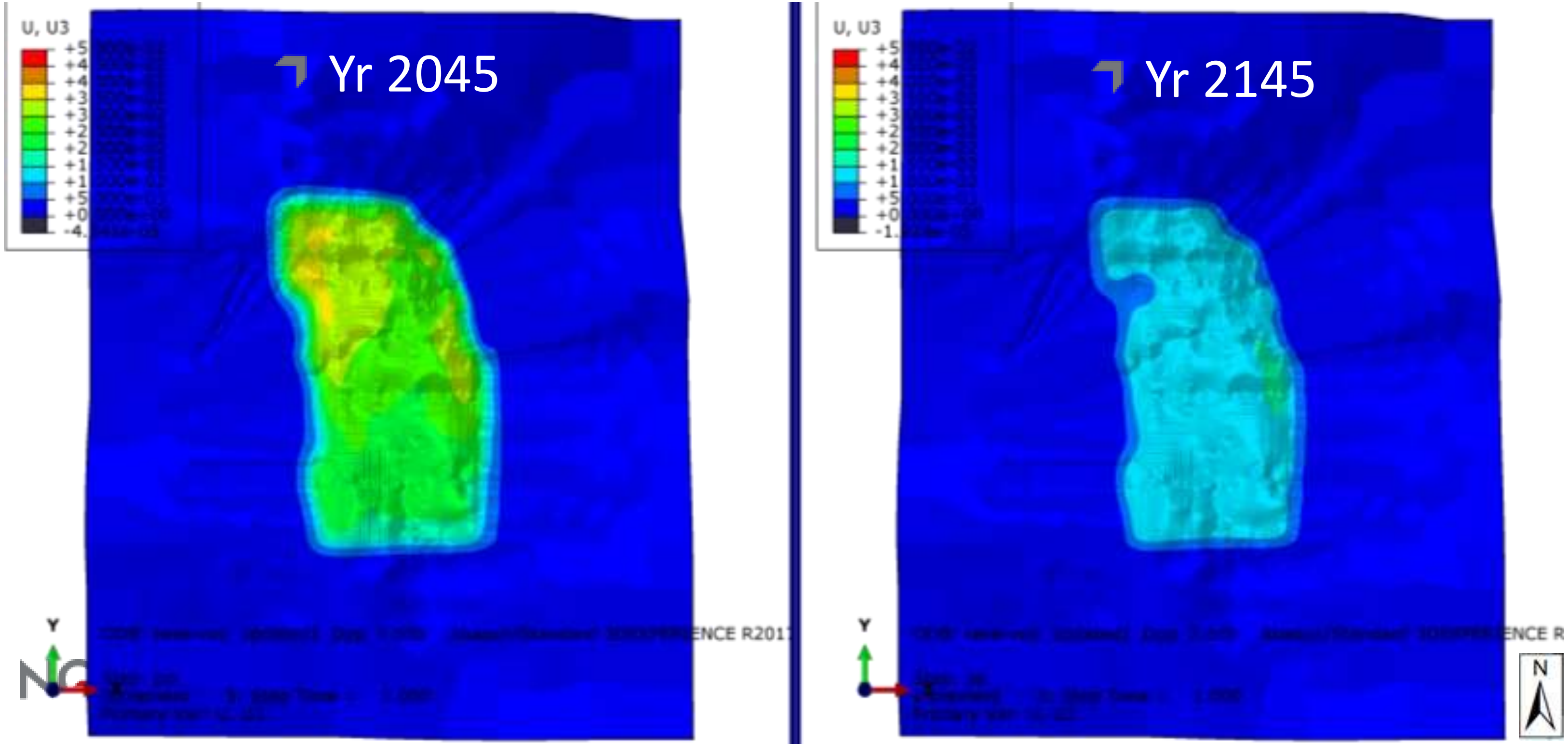


Seabed heave

- Maximum seabed heave is less than 5cm. Low risk on seabed geohazard

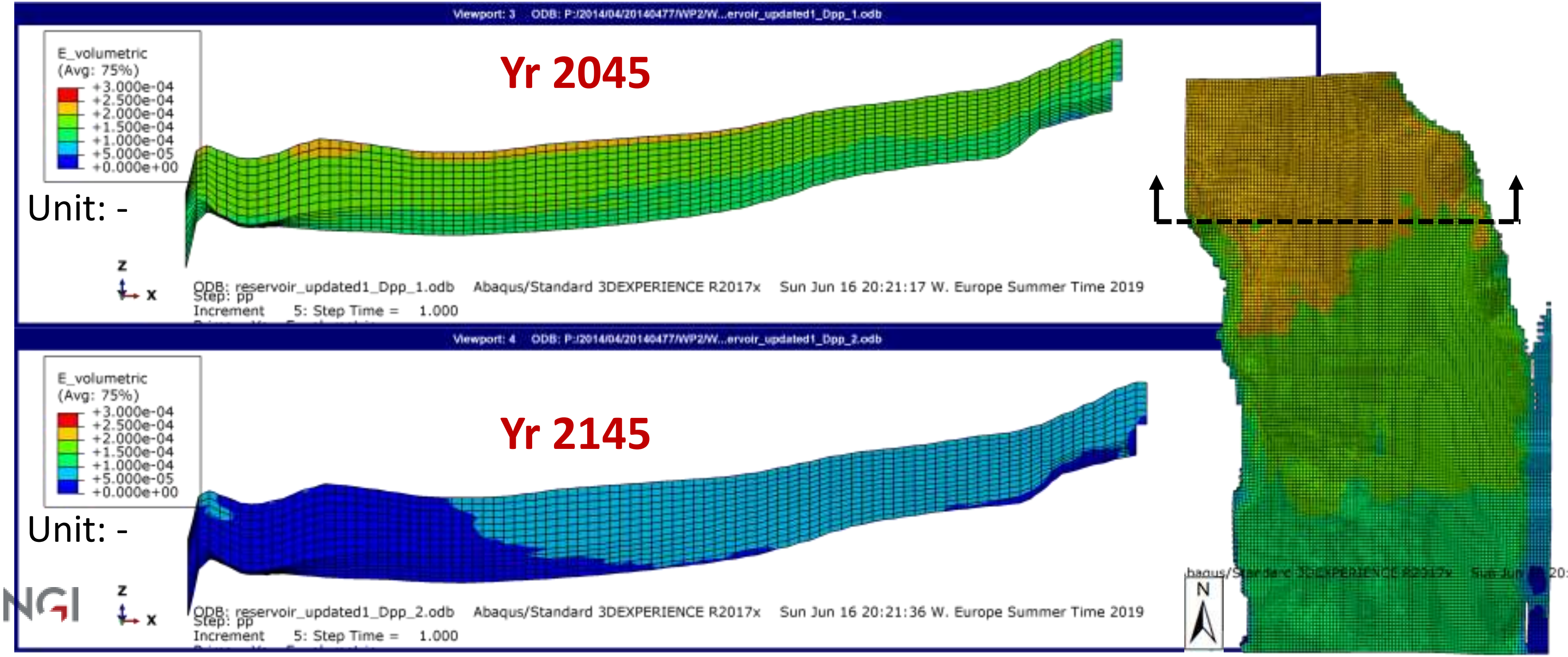


Unit: m



Injection-induced porosity change in the reservoir

- Porosity change is less than 0.1% during the injection



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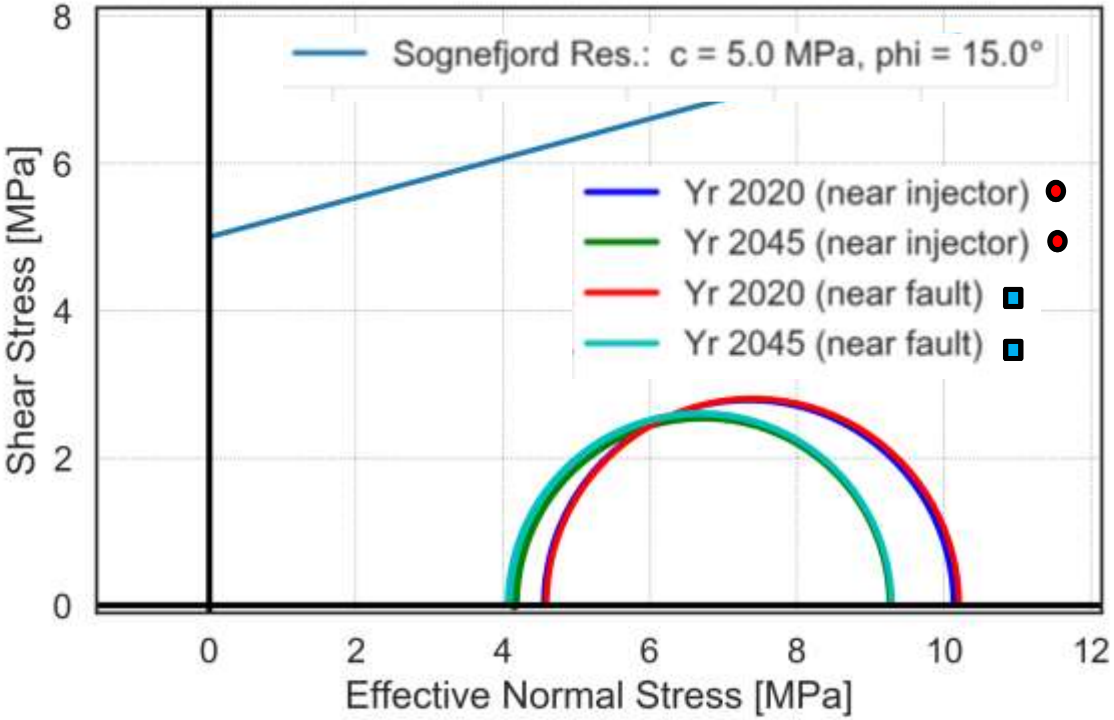
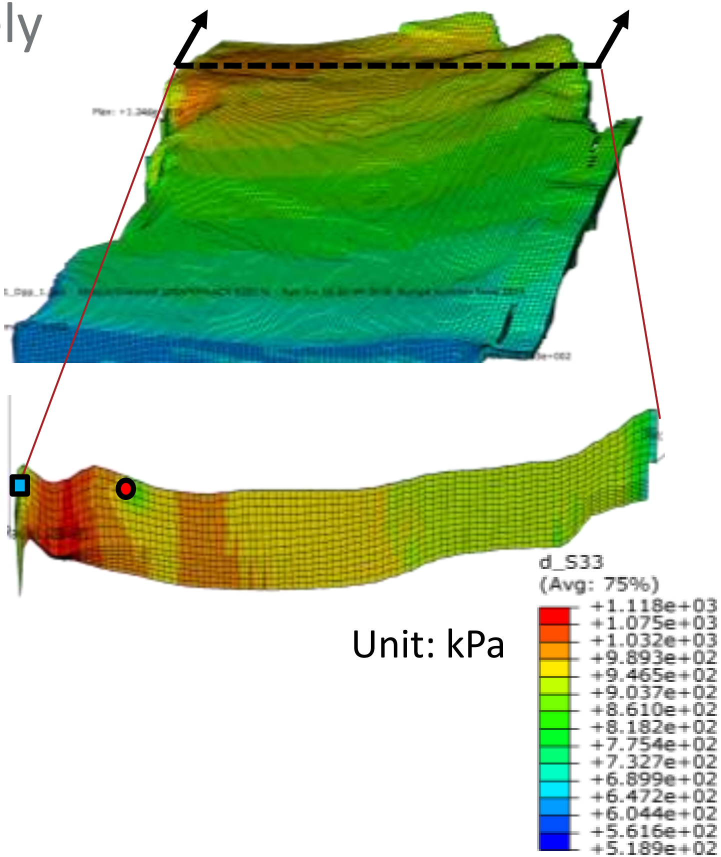
Stress path in reservoir

- Failure during the planned injection is unlikely



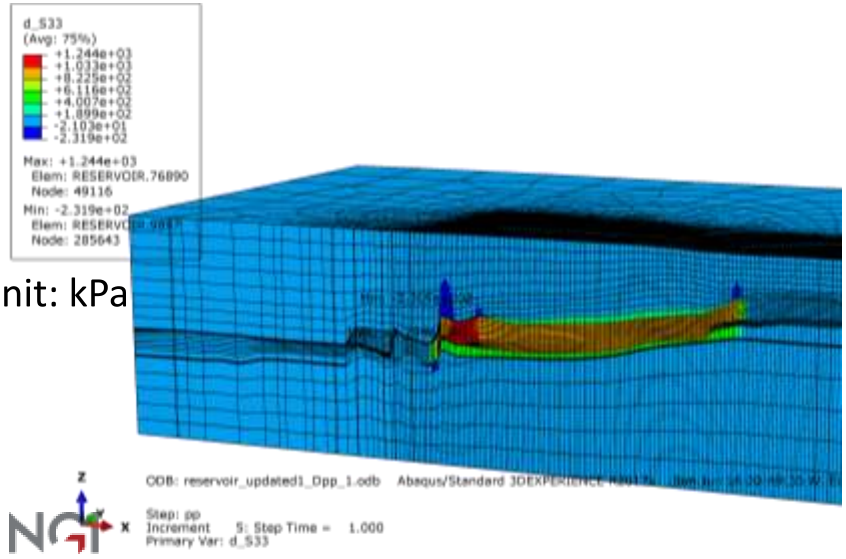
Vertical effective stress Yr2045



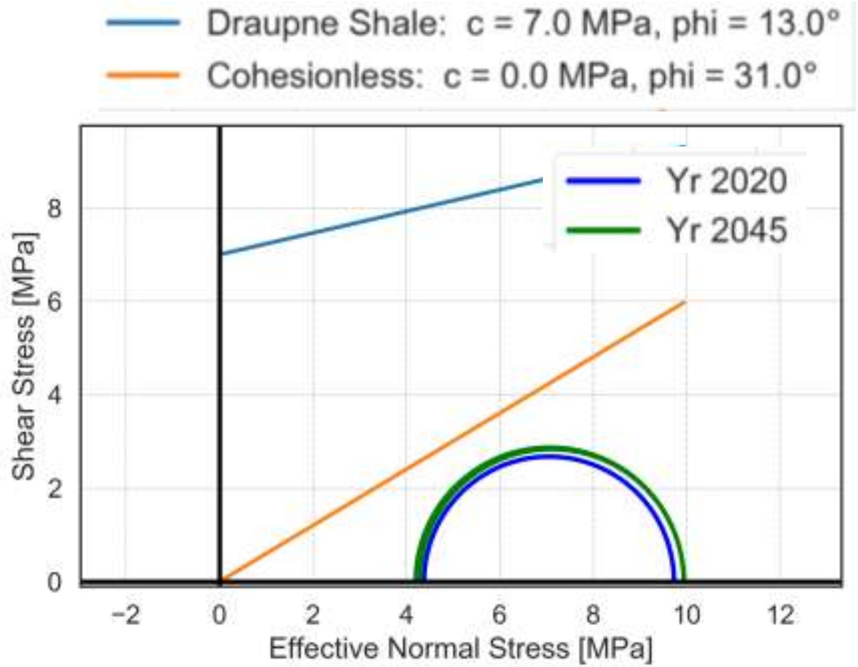
Stress change and integrity in the caprock

- Maximum stress change in the caprock is about 200 kPa (<20% max change in reservoir).
- Mechanical failure of caprock is unlikely for the selected injection scenario

Change in vertical effective stress Yr2045

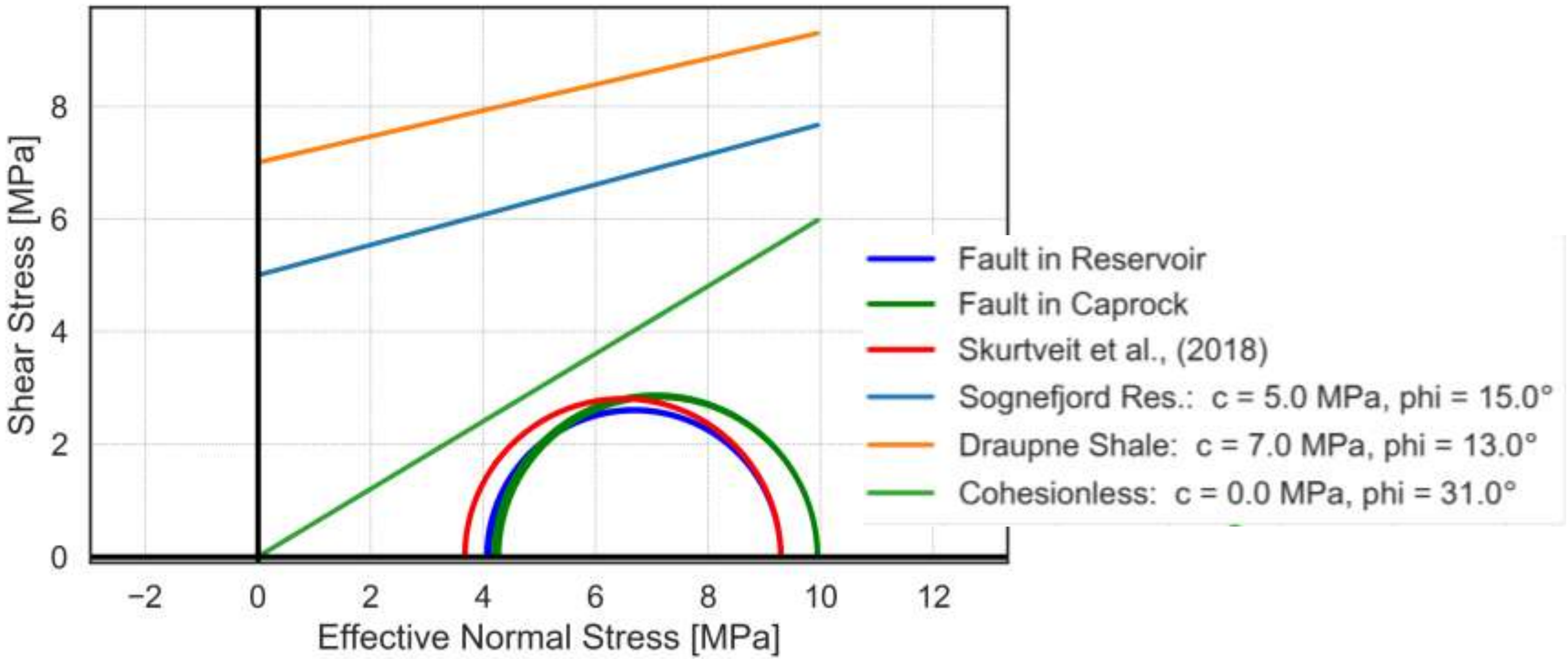


Unit: kPa



Stability of Vette fault

- In the given scenario, reactivation of Vette fault is unlikely.
- The analytical approach used in Skurtveit et al., (2018) seems to be conservative



Summary

- This study presents how to evaluate the geomechanical risk of CO_2 storage using a field scale 3D geomechanics model.
- For Smeaheia area, when the injection of 1.3 MT CO_2/yr during 25yrs at the SDL#2 is considered, the evaluated geomechanical risks are as follows:
  - Seabed heave and associated geohazard: Low
  - Injection-induced caprock integrity: Low
  - Injection-induced porosity change in reservoir: <1%
  - Reactivation of Vette fault: Low
- 3D geomechanics model is ready to investigate effects of various scenario easily. Further works incorporated with other research projects (SPHINCCS, OASIS, NCCS, IGCCS) are ongoing to investigate various scenarios (e.g. different injection scenario, effect of depletion in Troll, microseismicity, etc..)

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Thank you for your attention!

This publication has been produced with support from the NCCS Centre, performed under the Norwegian research program Centres for Environment-friendly Energy Research (FME). The authors acknowledge the following partners for their contributions: Aker Solutions, Ansaldo Energia, CoorsTek Membrane Sciences, Emgs, Equinor, Gassco, Krohne, Larvik Shipping, Norcem, Norwegian Oil and Gas, Quad Geometrics, Shell, Total, Vår Energi, and the Research Council of Norway.

Work was conducted in close collaboration with the Northern Lights project (Equinor, Total, Shell).

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