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

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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 CO2 storage capacity of 100 Mt each

(Equinor, 2016)
Geomechanics risk on Smeaheia

Key risks

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

Mulrooney et al., 2018
Previous study on derisking CO2 storage sites

Fault stability for Smeaheia area

2D geomechanics model for Snøhvit

Skurtveit et al., 2018

Choi et al., 2015
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
Modeling procedure

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

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

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Stress condition

Data from Northern Lights data package

- $K_0 = 0.45$
- $\Gamma_{v\text{ eff}} = 10.235 \text{ kPa/m from seabed}$
- $\text{Hydrostatic pp gradient} = 9.905 - 10.069 \text{ kPa/m}$
Material input

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

Porosity [-]

Young’s modulus [kPa]

Injection well SDL#1
Reservoir pressure

- Reservoir simulation 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.
Pressure build-up in the reservoir

Yr 2045

Unit: kPa

Yr 2145

Unit: kPa
Vertical deformation in reservoir

Yr 2045

Yr 2145

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.
Stress path in reservoir

Failure during the planned injection is unlikely

Vertical effective stress Yr2045

Unit: kPa
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
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 CO2 storage using a field scale 3D geomechanics model.

For Smeaheia area, when the injection of 1.3 MT CO2/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..)
Thank you for your attention!

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