Characterisation of European CO_2 storage

Evaluating the storage geomechanical stability

Valentina Volpi, Edy Forlin in collaboration with IFPEN, GEUS, IMPERIAL

Objectives

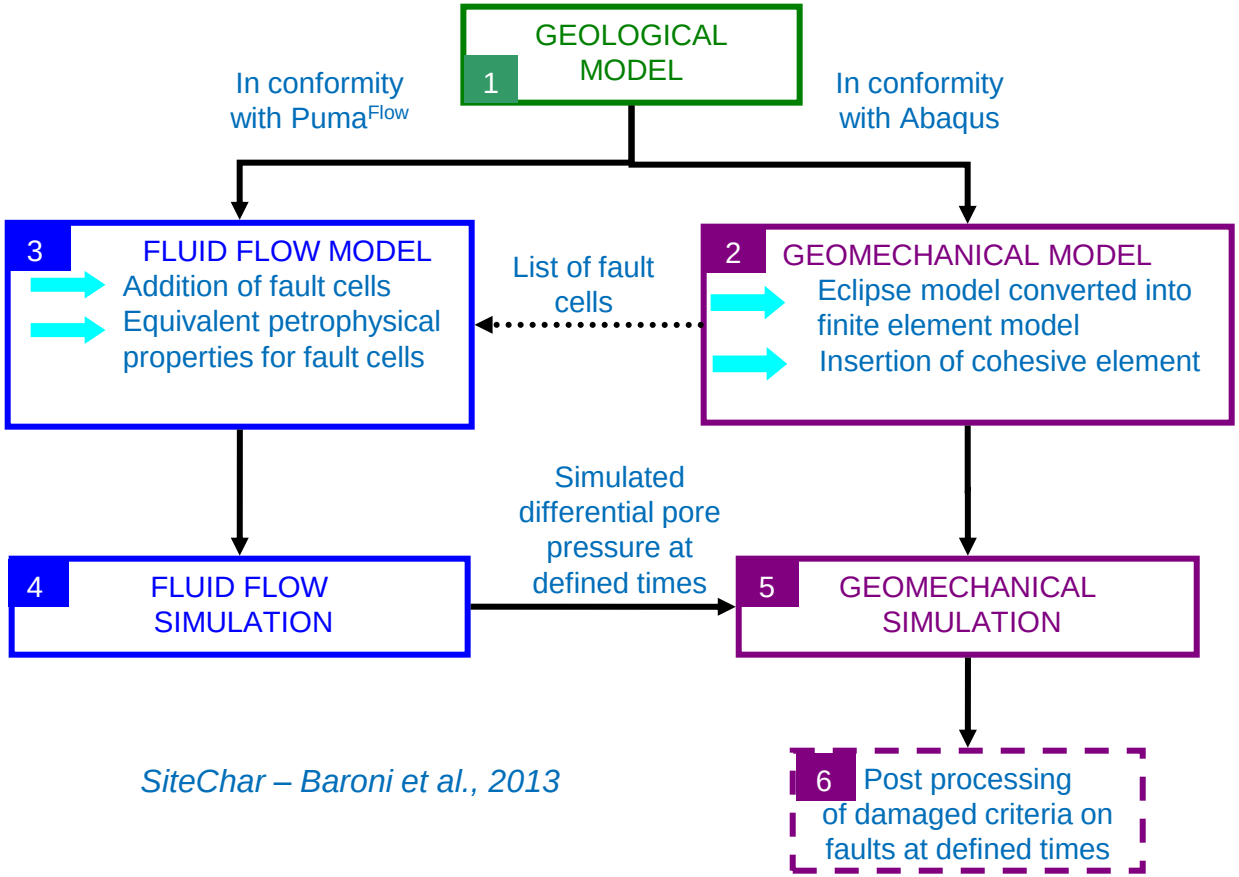
- **Evaluation of storage complex integrity**
  - threshold overpressure for caprock fracturing;
  - fault-related geomechanical risks;
  - seabed/topographic surface displacement evaluation;
  - potential migration pathways.
- **Planning injection strategy to reduce induced overpressure**

Challenges

- **Management of the lack of proper data**
  - Uncertainty analysis / Best and worst scenarios;
- **Strenghten the metodology**
  - Fluid flow – geomechanics coupling.

Workflow for geomechanical storage site charcterization

Southern Adriatic Sea site



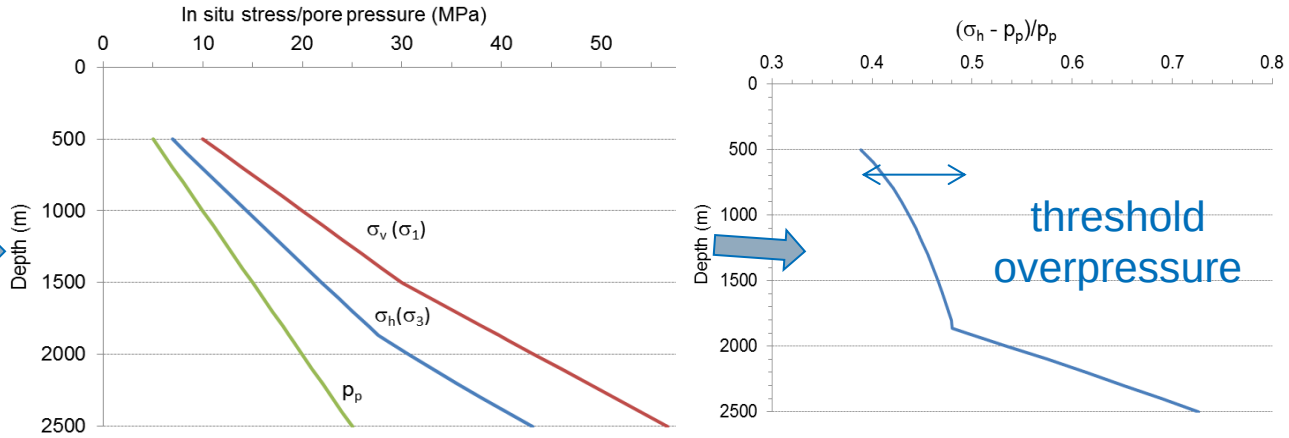
SiteChar – Baroni et al., 2013

Evaluation of the fracturing pressure

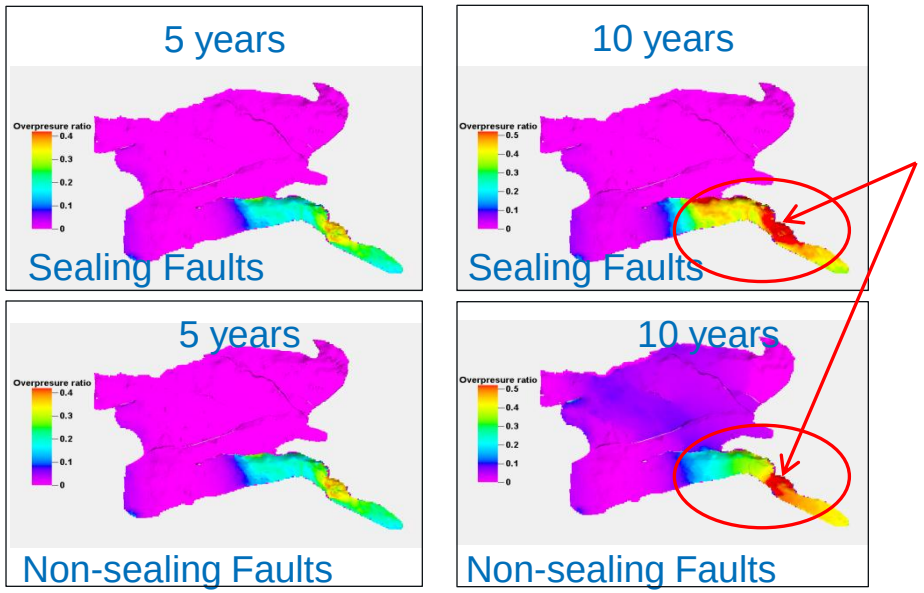
Outer North Sea - Moray Firth site

Pre-injection *in situ* stress:

- **well log data;**
- **leak-off test;**
- **borehole breakouts;**
- **pore pressure information;**
- **World Stress Map project.**



Simulated overpressure ratio distribution at 5Mt CO_2/year injection rate.



Several scenarios:

- **hydrodynamic fault behavior;**
- **petrophysical properties;**
- **injection rate.**

SiteChar – Shi et al., 2013

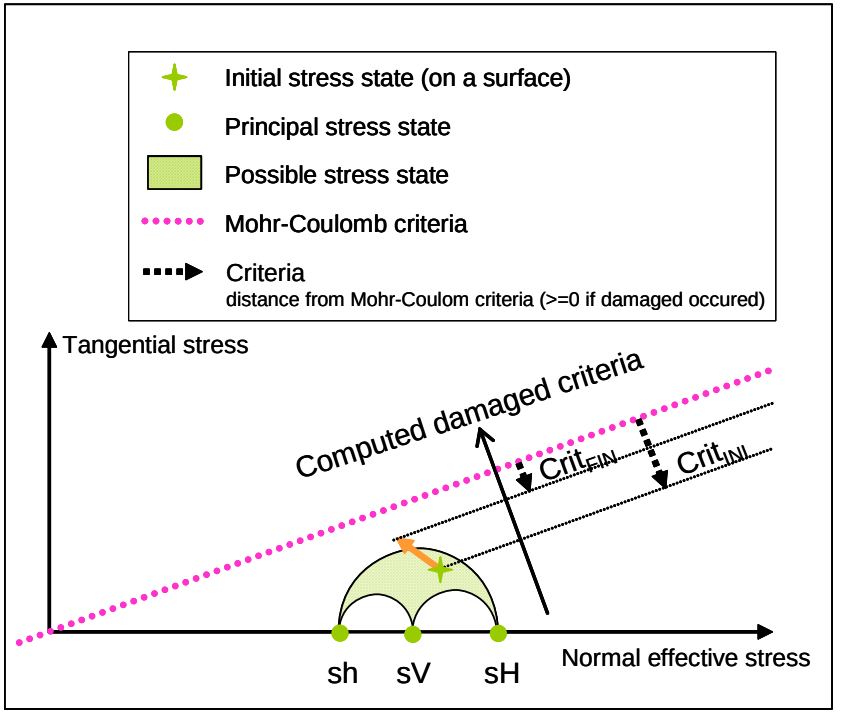
Fracturing could occur if injection at the rate of 5 Mt CO_2/year is continued beyond 5 years

Overpressure reduction actions such as fluid production must be taken

Analysis of geomechanical risks related to fault reactivation

Southern Adriatic Sea

- **Geomechanical modeling**
  - **Analysis of fault-related geomechanical risks:**
    - **comparing the fault stress state to a damage criterion;**
    - **Mohr-Coulomb criteria.**
  - **Sensitive analysis considering different scenarios:**
    - **in situ stress conditions;**
    - **hydrodynamic fault behavior;**
    - **petrophysical data.**

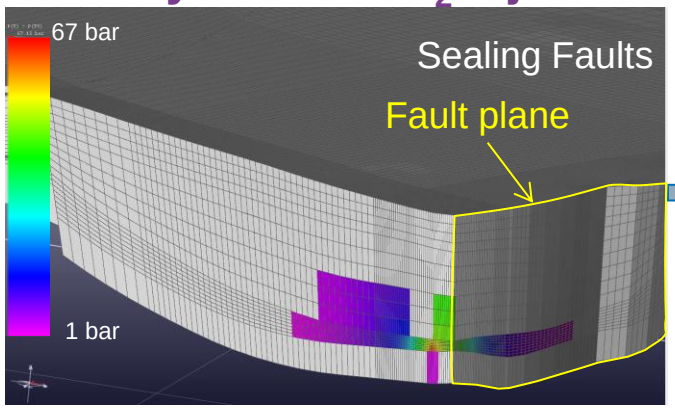


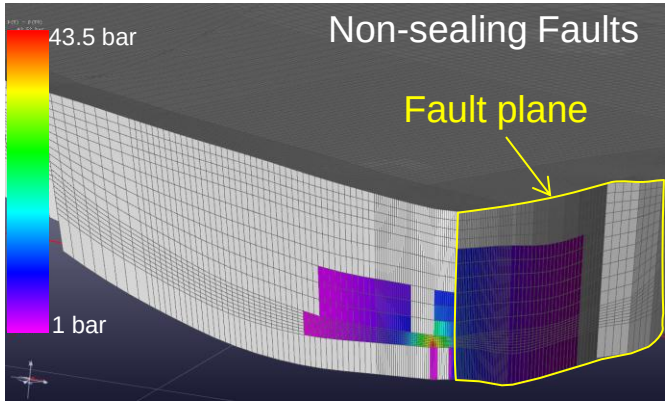
SiteChar – Baroni et al., 2013

Analysis of geomechanical risks related to fault reactivation

Southern Adriatic Sea

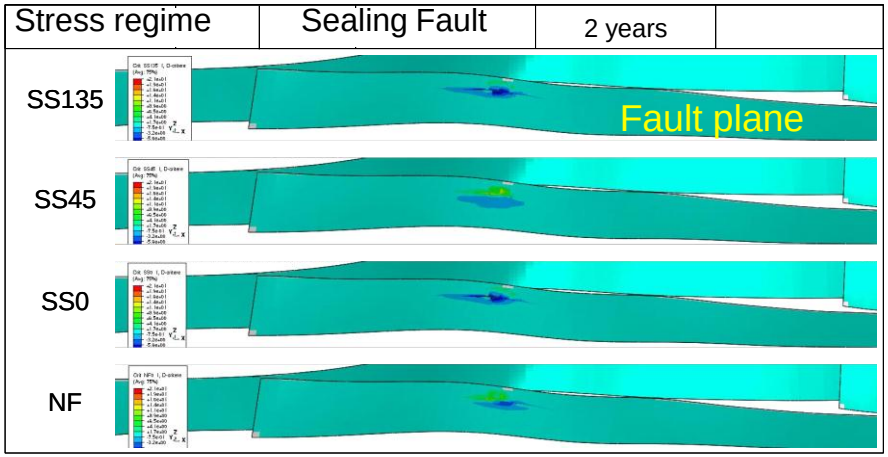
Simulated overpressure after 2 years of CO_2 injection

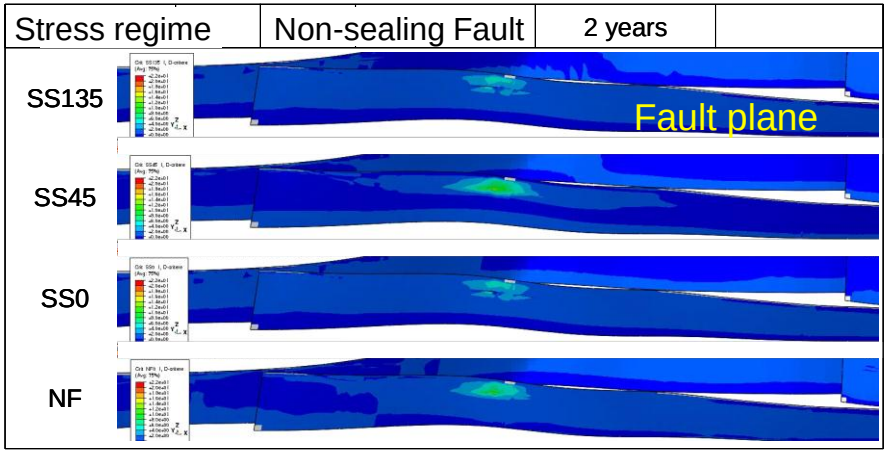




Geomechanical simulation results

$\Delta Crit = Crit_{END} - Crit_{INI}$



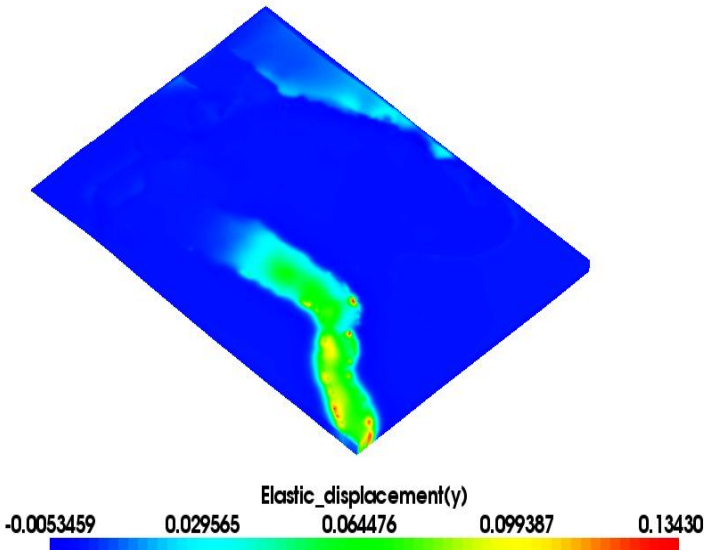


Sensitivity analysis ⟶ uncertainties managment

SiteChar – Baroni et al., 2013

Seabed/topographic surface vertical displacement evaluation

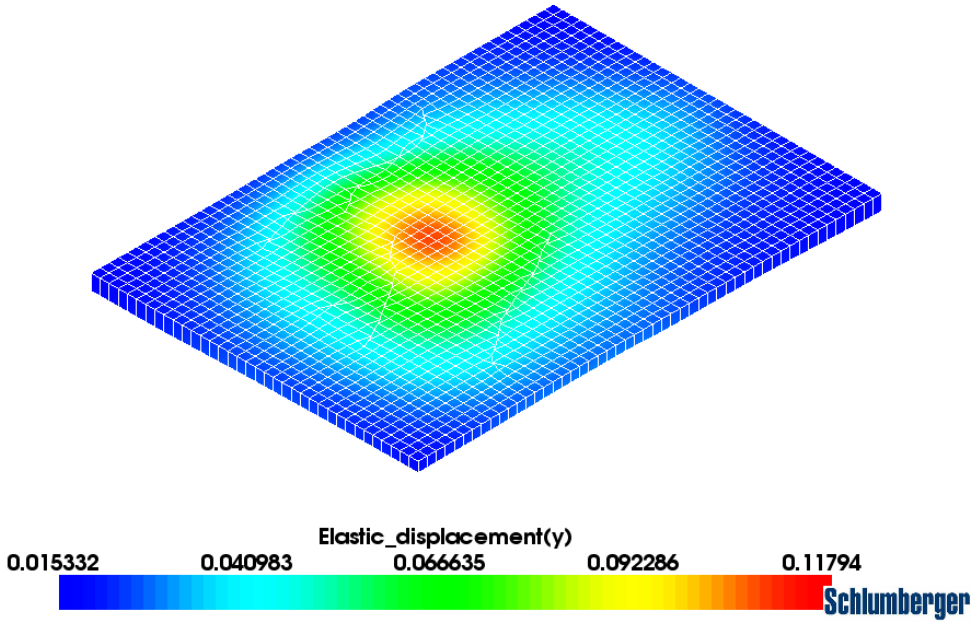
Outer North Sea - Moray Firth site



Seabed uplift (m) after 10 years injection. Injection rate: 5Mt CO_2 /year

SiteChar – Shi et al., 2013

North Denmark - Vedsted site



Surface uplift (m) after 40 years injection. Injection rate: 2Mt CO_2 /year

SiteChar – Nielsen et al., 2012

Key learnings from the SiteChar experience

- **Fault behaviour is a key element for the site characterisation/risk assessment**
  - **Lack of proper data**
  - **Simulations of different scenarios allow to evaluate fault impact deriving by their geometry and property uncertainties.**
- **Close collaboration between teams during all phases of the project:**
  - **purpose of the models;**
  - **software/format compatibility must be assured;**
  - **model extent and resolution;**
- **Interplay between regional and site scale model allows to assess pressure development outside the storage site to define the boundary conditions**

Remaining issues

- **Availability of proper data**
  - **reservoir heterogeneity;**
  - **information on fault properties;**
  - **overburden properties;**
  - **initial stress conditions (pre-injection stress state).**
- **Geomechanical and fluid dynamic simulations**
  - **Compatible geological models for geomechanics (faults) and fluid flow still requiring a lot of efforts;**
  - **model exchange/interaction among different site characterisation activities;**
  - **coupling strategy.**
- **Characterisation of earth movement to define safety margins of operation**

Recommendations

- **Close cooperation between teams/disciplines**
  - **Very close interaction between the static geological modelling, dynamic flow modelling and coupled flow and geomechanical modelling should be planned for the site characterisation work schedule.**
  - **Compatibility and interoperability among used softwares should be tested at the outset of the characterisation process.**
- **Sensitivity analysis**
  - **simulations of worst and best case scenarios might be a practical way to address lack of proper data.**

Acknowledgments

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