A Review of Fault Modelling Approaches

Lothe, A., Emmel, B.U., Lavrov, A., and Cerasi, P.

1 SINTEF Industry, P.O. Box 4763 Torgarden, 7465 Trondheim, Norway

Contact: Ane Lothe (ane.lothe@sintef.no)

Introduction

• In the subsurface the direct observation of fault is limited to well data and seismic imaging.
• Thus, numerical models are essential to estimate fluid flow in the subsurface at different scales.

Modelling approaches

Different strategies to model effect of faults on pore pressures and stresses using various meshes and grids.

Methods

Pore pressure modelling: For 3D pore pressure modelling over millions of years, the interpreted faults from seismic define the pressure compartments. Faults are assumed to be vertical, while the fault throws and permeability will vary with subsidence, erosion and uplift. The fault transmissibility depends on the burial depth, the length, width and the dip-slip displacement of the faults. The thickness of the layers and the permeability inside the fault block (Borge & Sylta 1998). The fault permeability can be calculated simply depending on the burial depth, or dependent on the shale gouge ratio along the fault planes (Sperrevik et al. 2002, Lothe et al. 2008).

Reservoir modelling: Faults are defined at grid block interfaces (Fig. 1b) and the transmissibility across a fault is modified using multipliers. Modelling is carried out using Eclipse 300.

Geomechanical modelling: In conventional finite-element modelling (FEM) faults are represented as collections of finite elements with reduced elastic moduli. When induced fracturing is of interest, the Modified Discrete Element model (MDEM) developed by SINTEF is used. Faults are described by aligning regular triangular elements as shown in Fig. 1c and assigning them different mechanical properties. Fluid coupling is obtained with the commercial flow simulator TOUGH2 or MRST (Lavrov et al. 2016).

Examples of user cases

• Basin scale overpressure: Sperrevik et al. (2002) is used to calculate permeability to faults in the study area. To simulate realistic transmissibilities, a cut-off value Vsh<0.4 is used (Lothe et al. 2008), resulting in stable runs (Fig. 3a). Faults are simulated to hold large pressures (Fig. 3b), as measured in wells in the North Sea case study.

• Detailed depletion effects: Using the reservoir simulator, fracture multipliers in all the mapped faults are tested (Fig 3c and d). The strength with reservoir models is that both water and gas phases can be handled, making it very nicely suited for e.g. CO2 capacity modelling. One weakness, is that new fractures cannot be modelled.

Conclusions

• Several approaches to model faults in sedimentary basins have been developed and applied in case studies at SINTEF recently.
• Different focus and methodology, depending on the scientific context motivating the research effort are shown from exploration, production and CO2 storage.

References:


CONTACT: Ane Lothe (ane.lothe@sintef.no)