Upscaled modelling of natural fracturing and leakage due to high overpressures

Ane Elisabet Lothe, Arnt Grøver, and Ole-Andre Roli
SINTEF Industry, Petroleum, Trondheim, Norway (ane.lothe@sintef.no)

In sedimentary basins highly overpressured formations and zones are observed worldwide. The high overpressures have been generated over millions of years due to sedimentation amount and rate, compaction, lateral fluid flow, diagenesis and other processes. The lateral fluid flow is often controlled by the fault pattern and sealing properties of the faults in the area, thus defining what is often termed pressure compartments. When high overpressures builds-up over time in such compartment, eventually natural hydraulic faulting and fracturing will start to develop to cease and relief the overpressure.

In this work we have aimed to simulate fracture generation, how they in an upscaled approach evolve and progress upwards, and how this will influence the water fluid flow and the pore pressure distribution. We use an in-house software (PressureAhead) to simulate three-dimensional water fluid pressure generation and dissipation over millions of years. Interpreted seismic horizons for the whole stratigraphy are back-stripped (decompaction) in order to provide the basin burial history as input to the forward simulator. Uplift and erosion events are included. For each timestep, the effect of pressure generation and dissipation is calculated. For the fault and failure development, the combined Griffith-Coulomb failure criteria are implemented to calculate when failure occurs, secondly, when the fracture has been formed and the cohesion is lost, the frictional sliding criteria is used. The fractures are in this approach working as a pressure valve, that will stay open as long as the pressure support is large enough. Compared to previous approach, the failure criteria is now evaluated for the whole stratigraphic column in 3D Using this approach, the effect of natural fracturing taking place in different parts of the basin at different geological events can be modelled.

The new simulation approach will be presented for a dataset from the deeper part of the Viking Graben, North Sea offshore Norway. The study area covers an NNE-SSW trending graben defined by large faults. Seventeen seismic horizons (resolution 50x50 m) from Middle Jurassic to seafloor have been used to set up the model. The modelling is carried out over the 150 My, with time steps of 250 000 years. Examples of varying key input parameters will be shown. Strength and weakness with such an upscaled modelling framework will be discussed.