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Coupling of Flow and Geomechanical Simulations for Short-term Underground Gas Storage - A Case Study from the Bavarian Molasse Basin

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Abstract

Modeling of underground gas storage (UGS) is a multi-disciplinary approach, which involves fully integrated subsurface processes. One important part is the coupled flow and geomechanical simulations to evaluate potential stress changes due to production and injection of the working gas volume. This aspect is of special relevance if short-term storage (days to weeks) with frequent injection-production cycles is considered. Modeling will help to define the maximum injection pressure and, thus, the storage capacity of the site in order to avoid fault reactivation and maintain cap rock integrity.

This geomechanical assessment concentrates on a former gas field in the Bavarian Molasse Basin east of Munich for which a hypothetical transformation to an UGS is considered. The workflow combines thermo-hydraulic (TH) calculations based on Eclipse with mechanical (M) simulations using the Techlog and Visage Software.

The Petrel model has been provided by industrial partner Uniper SE. The reservoir geometry was built up through seismic interpretation, thickness maps as well as through well data. The reservoir model is a faulted anticline structure located at a depth of about 1300 m with lateral dimensions of 4 km in N-S and 8 km in W-E direction, respectively. The pore pressure field has been derived from an Eclipse simulation through history matching for the production and subsequent shut-in phase. Production had started in 1958 and lasted till 1976. The shut in phase then started and field pressure increased again due to natural water drive. The 3D geomechanical model has been constructed by adding further stratigraphic sequences as over-and underburden rocks. This model is about 40 × 25 km^2 reaching to a depth of about 4500 m. The material properties (Young’s modulus, Poisson ratio, Biot’s coefficient, etc..) as well as a first guess for the vertical and horizontal stresses at well locations are derived using log data and 1D mechanical earth modeling (MEM) software Techlog, respectively. The calculated properties are calibrated with available core data and pore pressures for overburden and underburden rocks were calculated by using Eaton’s method. The 3D geomechanical model is coupled with Eclipse for further thermal-hydraulic calculations whereby pore pressure distribution, rock deformation, temperature and permeability within the reservoir play a vital role as coupling parameters. The state of the art is to bring reservoir engineering into the game and couple the 3D geomechanical model with the Eclipse model to analyze geomechanical stress changes due to injection-storage-production episodes in the storage reservoir.