Numerical modelling of production-induced stress changes and fault reactivation in Rotliegend gas fields of the North German Basin

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Production-induced seismicity is an increasing challenge to the oil and gas industry. For instance, hydrocarbon production from Rotliegend reservoirs in the Netherlands and northern Germany has triggered several seismic events in recent years. Available analytical models used to explain production-induced seismicity in relation to poroelastic stress changes cannot account for reservoirs with complex geometries, interference with far-field stresses and interaction with faults. In this study we develop generic numerical models to study production-induced stress changes and fault reactivation in and near compartmentalized Rotliegend gas fields of the Northern German Basin. Model geometries, material parameters and boundary conditions are inspired by the local situation but do not intend to describe a specific reservoir. A reference model with typical values serves as a basis for comparison to the results of the parameter variations in two model series. In model series I, we focus on stress changes in the linear-elastic domain for different input parameters. In model series II, a discrete fault modelled by a contact surface pair is incorporated into the model and we compute slip along the contact surface for different production scenarios and far-field stresses.

Results of models series I indicate field properties leading to an increase in production-induced promotion of normal faulting. Among others, a high Biot-Willis coefficient, a locally reduced overburden load and a large reservoir thickness shift the in situ stress towards more critical states. In model series II different fault friction coefficient are investigated. For the various production scenarios studied, the contact surface pair remains stable for $\mu > 0.6$, while for lower friction coefficients the contact surface pair eventually slips. Future work will expand the modelling concept to 3D in order to study more complex reservoir geometries.