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Stress-sensitive permeability: application to fault integrity during gas production

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Stress-sensitive permeability: application to fault integrity during gas production.

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The objective is to propose a simple theoretical approach and the associated numerical algorithm to capture the permeability evolution within a fractured region in response to a stress perturbation. The stress range of interest is typical of a reversible deformation such that the fractures have varying apertures but constant lengths and densities. It is the permeability evolution from a negligible value characteristic of flows on geological times to values more relevant for gas production which are important for the structural integrity of the fractured region. A simple 1D application related to the sealing capacity of a fault bounding a producing gas reservoir is proposed to illustrate the theory. The stress change on the two sides of the faults are obtained with a 2D finite-element simulation based on the theory of poro-elasticity and considering the fault as a material discontinuity. The 1D flow simulation is done in a second step and the flux is assumed to occur through the fault thickness from the non-depleted (minus side) to the depleted (plus side) regions. It is shown how the depletion results in the fractures opening in the fault damaged zone close to the minus side and the fracture closure next to the plus side. This evolution could be non-monotonic in time because of the development and the thinning of a boundary layer in the fluid pressure at the plus side. The simulations end once a Coulomb criterion is reached, typically at the minus side of the fault. The presence of a low-permeability core at the fault centre does not change these conclusions although a positive effective normal stress is detected in the damaged zone on the minus side of the core prior to the Coulomb criterion activation.