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Study of the influence of nearby fractures on coupled hydro-mechanical processes due to hydraulically induced fracture propagation

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The focus of the study is on understanding the influence of nearby fractures on the coupled hydro-mechanical effects due to hydraulically induced fracture propagation. Two rock domains were considered in comparison: FD1, with one fracture, and FD2, with two adjacent parallel or non-parallel fractures. The length of the fractures is 2 m. To study in detail the linkage between the two fractures in FD2, parallel and non-parallel fractures with different angles between them and the maximum horizontal boundary stress direction were considered. Simulations were made for a time period of 3 hours with an injection period of 2 hours followed by 1 hour of shut-in. An elastic-brittle model based on material properties degradation, was implemented in a 2D finite-difference scheme and used for elements subjected to tension and shear failure. A base case was considered in which several key parameters are fixed at reasonable values. Those are the closest distance dF between the two natural fractures, the ratio SR between the boundary stress magnitudes, the permeability kR of the intact rock, and the permeability kTF of the tension failure regions. Then, a sensitivity study to analyse the influence of those parameters on the simulation results, was made.

Results show that the propagation of a single fracture was significantly greater than the propagation of a double fracture system because, in the latter case, the pore pressure decreased when the two fractures connected. As a result, changes in permeability in FD2 were smaller than in FD1. For non-parallel fractures, the controlling factor for fracture propagation was the separation between the tips of the pressurised fracture and the neighbouring non-pressurised fracture.

Results of the sensitive analysis showed that when (1) the distance between the two natural fractures increases, the pressurised fracture extends more, and the effect of linkage between fractures on their propagation decreases; (2) the ratio between the boundary stress magnitudes increases, the minimum fluid pore pressure value necessary to initiate fracture propagation decreases; (3) the permeability of the intact rock increases, the pore pressure around the fracture tip decreases, which results in a decrease in the fracture propagation; and (4) the permeability of tension failure regions decreases, the fractures may connect, but the difference in fluid pore pressure observed in the two fractures increases.