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Study of the influence of geological features and key parameters on coupled hydro-mechanical processes in hydraulic fracturing of shale-gas reservoirs

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The focus of the study is on understanding the influence of complex geological settings and key parameters on hydraulically induced fracture propagation in shale-gas reservoirs. This is accomplished by coupled hydro-mechanical analyses of different scenarios of hydraulic fracturing starting from a 2-m long vertical injection fracture. The influence of neighboring confining formations, bedding planes and pre-existing faults on the hydraulic fracturing process with an injection period of two hours is studied. 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 sensitivity analysis was also carried out to study the influence of key parameters on the simulation results. These are the ratio between the horizontal and vertical stresses, the permeability of the confining formations, the initial fault permeability and the initial permeability of the bedding planes.

Results show that nearby bedding planes and pre-existing faults limit the fracture propagation since they are softer than the surrounding shale formation. This leads to an increase in the injection pressure for a given injection rate. Permeability changes in the injection fracture were found to be larger when the water injection occurs near a bedding plane with very small initial permeability because of a major increase in the injection pressure. Those changes are smaller when the water injection occurs near a pre-existing fault, because of changes in the fault permeability.

Further, it was found that fracture propagation is strongly influenced by the ratio between the horizontal stresses and by the permeability of the confining formations. Thus, the fracture propagation stops at the boundary with the confining formations when (1) the confining formations are significantly more permeable than the shale formation or (2) the horizontal stresses in those confining formations are larger than in those in the shale formation. On the other hand, when the initial permeability of the pre-existing fault or bedding planes is significantly larger than that of the shale formation, the pore pressure in the injection fracture increases less and the fracture stops to propagate when it reaches the confining formations.