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An approach to simulate coupled fracture propagation and fluid flow in fracture-matrix systems

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Hydraulic stimulation is a frequently applied approach to improve the productivity of geothermal and low-permeability oil and gas reservoirs. In geothermal reservoirs stimulation generates large-scale fractures to obtain a high exchange area between the reservoir and fluid flow taking place in the fractures. Also, the production is increased by the increased flow rate in the fracture.

Hydraulic and mechanical processes taking place in and around fractures are complex. Especially, the coupling between them makes the numerical simulation a challenging task. Hydraulic fluid flow in the fractures is affected by the structure of the rough fracture surfaces and by the leak-off into the surrounding rock matrix. In addition, the fracture aperture depends on the interplay between fluid pressure and rock stresses. Fracture propagation is an additionally appearing phenomenon when the stress at the fracture tip exceeds a critical value. The stress at the fracture tip is a result of the pressure distribution in the fracture, so that again a coupling mechanism exists. The numerical simulation of these coupled processes becomes complicated due to the different approaches which need to be used for the simulation of the involved processes, whereas rock mechanical and hydraulic processes are commonly simulated by continuum-based discretization approaches, the simulation of fracture propagation requires approaches like the displacement discontinuity method (DDM).

In this contribution a concept is proposed to simulate the coupled processes of fracture propagation and fluid flow in fracture-matrix systems. The idea behind the concept is to calculate each process separately. The coupling between the processes is realized by exchanging primary variables and parameters between each simulation package. The

overall solution is obtained by iteratively solving the problems until convergence is achieved. The overall simulation is composed of three sub-packages for the simulation of fracture propagation, fracture flow and matrix flow. First implementation results will also be presented.