Investigating mini hydraulic fracturing using discrete element modeling of foliated rock with different fluid viscosities

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Abstract

Several mini hydraulic fracturing tests were performed in several boreholes located in central Hungary in order to determine the in-situ stress for a geological research program. At depth of about 540 meters, the observed pressure versus time curves in mica schist with low angle, sub-horizontal foliation show atypical results. After each pressurization cycle, the fracture breakdown pressure in the first fracturing cycle is lower than the reopening or refracturing pressures in the subsequent reopening and jacking (variant of the constant pressure packer test) phases. It is assumed that the composition of the drilling mud and observed foliation of the mica schist have a significant influence on the pressure values. In order to investigate this problem, numerical modeling was performed using the discrete element code PFC (Itasca's Particle Flow Code), which has been proven as an effective tool to investigate rock engineering problems associated with hydraulic fracturing. The code presented in this study enables simulating hydro-mechanically coupled fluid flow in crystalline rock with low porosity and pre-existing fractures in two dimensions. In this study, the sensitivity of the effect of foliation angle and fluid viscosity on the peak pressure is tested. The anomalous characteristics of the pressure behavior are interpreted in that way that the fluid with higher viscosity penetrates the sub-horizontal foliation plane, it blocks the plane of weakness and makes the opened fracture tight, i.e. higher pore pressure decreases slowly. Eventually, the viscous blocking process prevents leak-off from the opened fracture that might explain the increased fracture reopening pressure in subsequent cycles.