EGU21-7810, updated on 27 May 2022
https://doi.org/10.5194/egusphere-egu21-7810
EGU General Assembly 2021

Challenges in correctly assessing fracture growth in subsurface applications

Morteza Nejati[1], Mahsa Sakha[1], Bahador Bahrami[1], Saeid Ghouli[2], Majid R. Ayatollahi[2], and Thomas Driesner[1]
[1]Institute of Geophysics, ETH Zurich, Zurich, Switzerland (mnejati@ethz.ch)
[2]Department of Mechanical Engineering, Iran University of Science and Technology, Tehran, Iran

Accurate predictions of fracture growth path resulted from fluid injection in subsurface is an important topic in geoscience projects such as wastewater injection, CO2 sequestration and geothermal energy extraction. Pressurised fluid not only creates new fractures in form of hydraulic fractures, but also potentially propagates pre-existing ones. A precise assessment of fracture growth path is pivotal in characterising the connectivity of the fracture network, and as a result, the hydraulic response of the rock volume. Numerical modelling provides a strong platform to help better understand fracture growth path during hydraulic stimulations. Despite significant progress in the computational power and advanced numerical algorithms in recent years, the numerical simulation of fracture growth still faces many challenges. Some of these challenges are related to the robustness of the numerical schemes used to model evolving fractures. The development of methods such as extended finite element and phase-field have greatly helped in recent years to tackle the evolution of fractures in complex trajectories. A second group of challenges is related to the development of accurate fracturing laws and their implementation into numerical codes in order to obtain realistic fracture growth trajectories. In this paper, we address some of the challenges in the second group and share our findings on how we can more accurately predict fracture path in subsurface. At first, we present our evaluation of the measured values of the fracture toughness in laboratory, and discuss why those values are mostly underestimating fracture toughness in rock masses. We then introduce a method to correct these values, that are obtained from small laboratory-sized specimens, to be able to use them in numerical codes that predict fracture growth in large rock volumes in subsurface. The second contribution is related to the rock anisotropy and its influence on the fracture growth path. We present experimental results on the anisotropy of fracture toughness, and show how important it is to take into account the directional-dependence of fracture toughness when modelling fracture growth in anisotropic formations. Lastly, the third contribution is to distinguish between tension-based and shear-based fracture growth mechanisms. Most numerical models in literature use the maximum tangential stress criterion to predict fracture growth path. We show that this criterion is not able to predict shear-based fracturing that often occurs in the subsurface. We conclude that a reliable numerical code needs to implement a fracturing law that is able to predict both tensile- and shear-based fracturing types.