Impact of Layering and Mineral-Fabric Orientation on Fracture Surface Roughness

Laura J. Pyrak-Nolte[1,2], Liyang Jiang[1],Antonio Bobet[3] and Hongkyu Yoon[4]

[1]Department of Physics and Astronomy, Purdue University, West Lafayette, IN, United States
[2]Department of Earth, Atmospheric and Planetary Sciences, Purdue University, West Lafayette, IN, United States
[3]Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, United States
[4]Geomechanics Department, Sandia National Laboratories, Albuquerque, NM, United States

Fractures are one of the dominant factors that influence the success or failure of subsurface activities related to geothermal energy development, gas production and storage of anthropogenic fluids in the Earth's subsurface. How fractures form and propagate in rock affects the geometry of the voids and contact area that define the fracture flow paths rocks. Failure in rock is a progression of energy transfers from the smallest scales (lattice or microstructure) to potentially the full scale of a rock system under consideration. At the mineral scale, the mineral composition, distribution, orientation and bonding among minerals are known to affect the engineering properties of a rock in addition to the presence of structural features such as micro-cracks, layers and other sources of porosity. One difficulty in performing experiments to link macro-scale behavior to micro-scale features and the composition of rock is the inherent presence of heterogeneity in mineral composition and structural features that occur among samples taken from the same formation or block of rock, and even within a single sample.

Here, we examined the effect of layering and mineral orientation on fracture roughness using additively manufactured rock. The synthetic rock was created through 3D printing with bassanite/gypsum powder. The 3D printing process enabled control of the orientation of the mineral texture within the printed layers. Three-point bending (3PB) experiments were performed on the 3D printed rock with a central notch. Generation, suppression and enhancement of corrugations in the fracture surface roughess depend on the relative orientation between in layer mineral fabric and layering. These insights into the role of micro-scale structure on macro-scale flow provide a new method for designing subsurface strategies to maximize potential production or to inhibit flow.

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