Modified Invasion Percolation on Fracture Networks

Salomon Wettstein

ETH Zürich, Institut für Baustoffe
Betreuer: F. Wittel
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The main purpose of this Master thesis is to simulate two phase flow in the form of gas-water displacement through anisotropic, three-dimensional (3D) discrete fracture networks (DFN). The considered DFN's are artificially generated, based on a general distribution function or on measured distributions by the Nagra ("National Cooperative for the Disposal of Radioactive Waste") as described in the preliminary work ([1, 2]). The latter led to this collaborative thesis between Nagra and the Institute for Building Materials (IfB). The modified invasion percolation (MIP) is the main tool that is applied on the different models. The MIP allows the incorporation of the fracture inclination and the line of intersection length between connected fractures, as well as the hydraulic path length in the fracture itself. Both phases (gas and water) are treated as incompressible and a trapping algorithm is implemented, that forbids any advance of gas into a region, where the water is completely encircled by gas and has no escape route.

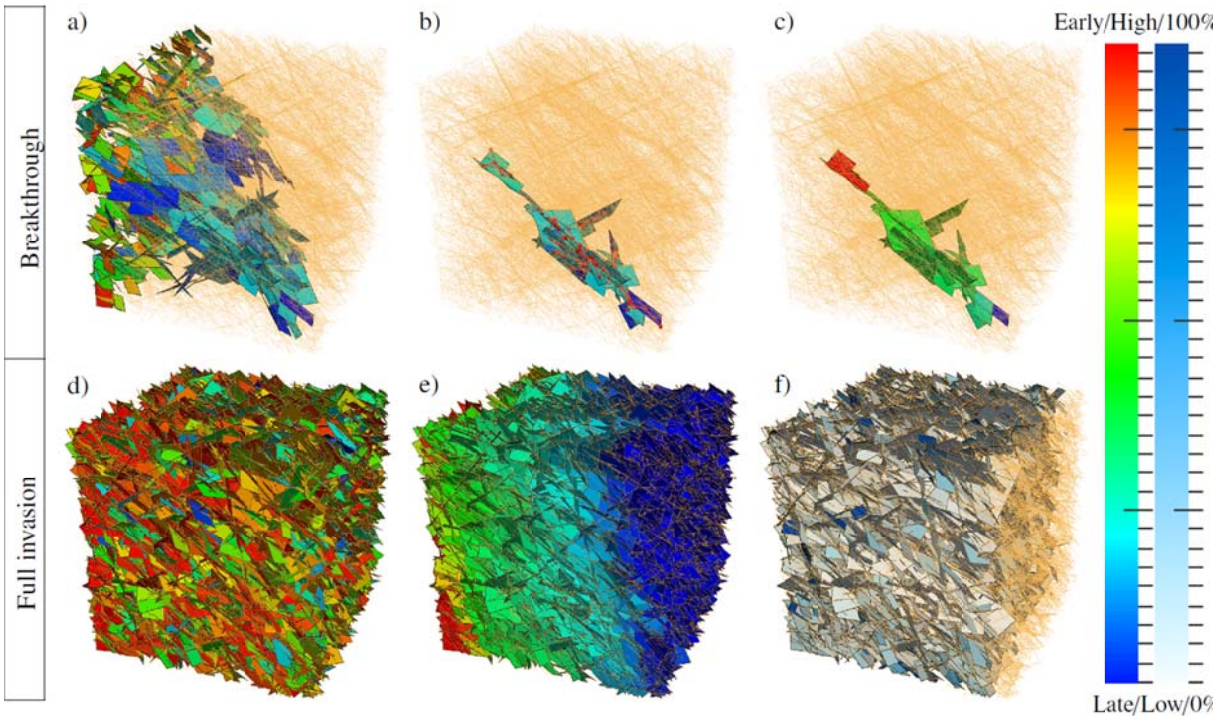

Figure: Wellenberg DFN at breakthrough and after full invasion.
a) Invaded fractures at breakthrough marked from early (red) to late invasion (blue) after trapping MIP from left y = 0 to right y = 100 m. b) Flow fracture network (backbone of the percolation cluster) and channel model discretization of the non-pruned fractures. c) Pressure distribution in the flow fracture network. The fractures are colored according to the mean pressure on the fracture plane. Red indicates high and blue low pressure. d) Invaded fractures after continuing the invading process till full invasion with trapping MIP. e) Pressure distribution in the flow fracture network. f) Invaded fractures that contain trapped water. Colors indicate the amount of trapped water from fully trapped with 100% (dark blue) water content to non-trapped (fully invaded) with 0% (white) water content. Transparent fractures at the exit zone (representing the outlet) are not identified (no trapping possible).