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Influence of Aperture Distribution on Flow in Fractal-Fracture Networks

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While fractal models are often employed for describing the geometry of fracture networks, a constant aperture is mostly assigned to all the fractures when such models are flow simulated. While network geometry controls connectivity, it is fracture aperture that controls the conductivity of individual fractures as described by the well-known cubic-law. It would therefore be of practical interest to investigate flow patterns in a fractal-fracture network where the apertures also scale as a power-law in accordance to their position in the hierarchy of the fractal. A set of synthetic fractal-fracture networks and two well-connected natural fracture maps that belong to the same fractal system are used for this purpose. The former, with connectivity above the percolation threshold, are generated by spatially locating the fractured and un-fractured blocks in a deterministic and random manner. A set of sub-networks are generated from a given fractal-fracture map by systematically removing the smaller fracture segments. A streamline simulator based on Darcy's law is used for flow simulating the fracture networks, which are conceptualized as two-dimensional fracture continuum models. Porosity and permeability are assigned to a fracture within the continuum model based on its aperture value and there is nearly no matrix porosity or permeability. The recovery profiles and time-of-flight values for each network and its dominant sub-networks at different time steps are compared.

The results from both the synthetic networks and the natural maps show that there is no significant decrease in recovery in the dominant sub-networks of a given fractal-fracture network. It may therefore be concluded that in the case of such hierarchical fractal-fracture systems with scaled aperture, the smaller fractures do not significantly contribute to the fluid flow.

Key-words: Fractal-fracture; Connectivity; Aperture; Dominant Sub-networks; Streamline Simulator; Recovery