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Macroscopic properties of polydisperse, anisotropic and/or heterogeneous fracture networks

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Our purpose is to address three systems with variable properties as they exist in nature. In polydisperse networks, the lateral extension of the fractures follows a power law. In anisotropic networks, the normals to the fracture planes obey a Fisher distribution. In heterogeneous networks, the spatial distribution of the local density is random and is derived from a Gaussian field correlated by a Gaussian function.

The numerical technique is based on a three-dimensional discrete description of the fracture network. Any fracture network geometry, any type of boundary condition, and any distribution of the fracture can be addressed. The first step is to mesh the fracture network as it is by triangles of a controlled size. The second step consists in the discretization of the conservation equations by the finite volume technique. Two important properties were studied, namely the percolation threshold and the macroscopic permeability of the fracture network.

The interpretation of the numerical results is made with the concept of excluded volume which enables us to define a dimensionless fracture density rho' equal in the average to the average number of intersections per fracture. When the macroscopic properties are represented in terms of rho', the dimensionless curves are independent of the fracture shape.

For polydisperse networks, the influence of various parameters such as the domain size, the exponent of the power law, the smallest radius and the fracture shape on the percolation threshold and on the permeability of fracture networks has been numerically studied. A unique expression is proposed for the percolation threshold which even holds for mixtures of shapes. Two analytical formulas for the permeability are proposed which successfully fit the numerical data over a wide range of network densities.

For anisotropic networks, the percolation threshold is influenced by anisotropy, but it does not depend on the spatial direction, a feature which does not apply for permeability.

Several recent extensions will be briefly addressed to conclude this overview, such as the properties of fractured porous media with fractures of random size, and of fracture networks with variable fracture permeability.