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Percolation of fracture networks and stereology

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The overall properties of fractured porous media depend on the percolative character of the fracture network in a crucial way. The most important examples are permeability and transport.

In a recent systematic study, a very wide range of regular, irregular and random fracture shapes is considered, in monodisperse or polydisperse networks containing fractures with different shapes and/or sizes. A simple and new model involving a dimensionless density and a new shape factor is proposed for the percolation threshold, which accounts very efficiently for the influence of the fracture shape. It applies with very good accuracy to monodisperse or moderately polydisperse networks, and provides a good first estimation in other situations. A polydispersity index is shown to control the need for a correction, and the corrective term is modelled for the investigated size distributions.

Moreover, and this is crucial for practical applications, the relevant quantities which are present in the expression of the percolation threshold can all be determined from trace maps. An exact and complete set of relations can be derived when the fractures are assumed to be Identical, Isotropically Oriented and Uniformly Distributed (I2OUD). Therefore, the dimensionless density of such networks can be derived directly from the trace maps and its percolating character can be a priori predicted.

These relations involve the first five moments of the trace lengths. It is clear that the higher order moments are sensitive to truncation due to the boundaries of the sampling domain. However, it can be shown that the truncation effect can be fully taken into account and corrected, for any fracture shape, size and orientation distributions, if the fractures are spatially uniformly distributed.

Systematic applications of these results are made to real fracture networks that we previously analyzed by other means and to numerically simulated networks. It is important to know if the stereological results and their applications can be extended to networks which are not I2OUD. In other words, for a given trace map, an equivalent I2OUD network is defined whose percolating character and permeability are readily deduced. The conditions under which these predicted properties are not too far from the real properties are under investigation.