Characterization of permeability based on topological data of fracture network

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Fracture structures controls fluid flow in rocks. The distributions of 3D fracture networks is difficult to be distinguished, and it is not possible to directly estimate the flow properties unless information related to flow (e.g., fracture apertures, connectivity) can be obtained. Persistent homology is a method for computing topological features of shapes and functions, which provides complex and multiscale geometric information in large datasets. This study applies persistent homology to analyzing fracture network patterns in order to understand the relationship between flow properties and fracture structures. We considered fracture aperture distributions and flow paths in fracture networks can be derived from the parameters of persistent homology, which can estimate the permeability of the fracture network. Synthetic 3D fracture network patterns were generated and used to validate the method to estimate permeability. Direct simulation of fluid flow was conducted by using the same fracture networks. The results show that opening aperture distributions of flow paths could be obtained by persistent homology analysis and that estimated permeability was almost the same order of magnitude as the permeability derived from the simulation. Persistent homology can contribute to characterize the relationship between structures and flow.

Keywords: 3D Fracture network, Permeability, Persistent homology, Image analysis, Direct simulation

