Stochastic Modelling *of* Fractures *in* Rock Masses

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Dedication

to my mother and my father

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Abstract

Fracture and fracture network modelling is a multi-disciplinary research area. Although the literature in general is significant, many research challenges remain. The complex geometry and topology of realistic fracture networks largely determine the static and dynamic mechanical properties of rock. In applications to hot dry rock geothermal reservoirs it is not possible to observe or measure fractures directly on any scale and the only data available are indirect measurements, such as seismic activity generated by hydraulic fracture stimulation. The lack of direct data and the complexities of the fracture characteristics make fracture network prediction and modelling in these applications very difficult. The ultimate purpose of the fracture and fracture network models is to evaluate the response of the fracture system to stress regimes and fluid flow. As understanding of the effective factors in the geometrical modelling of fractures and consequently topological properties of fracture networks increases, more accurate and hence more reliable results can be achieved from associated analyses. For flow modelling in geothermal reservoirs, the critical component of a fracture model is the connectivity of the fractures as this determines the technical feasibility of heat production and is the single most significant factor in converting a heat resource to a reserve. The ability to model this component effectively and to understand the associated system is severely constrained by the lack of direct data. In simulations, the connectivity of a fracture network can be controlled to a limited extent by adjusting the fracture and fracture network parameters (e.g., locations, orientations) of the defining distribution functions. In practical applications connectivity is a response of the system not a variable. It is essential to pursue modelling methods that maximise the extraction of information from the available data so as to achieve the highest possible accuracy in the modelling. Although the evaluation of fracture connectivity is an active research area, widely reported in the literature, almost all connectivity measures are based on degraded representations of the fracture network i.e., lattice-based. The loss of fracture connectivity information caused by using discrete representations is significant even when very high resolutions (assuming they are feasible) are used. This is basically due to the fact that the aperture dimensions of fractures are several magnitudes smaller than their lengths. If discretisation is necessary, then a better approach would be to retain all connectivity information between fractures, i.e. for connectivity information to remain invariant to the resolution of the discretisation. Such a method would provide more reliable evaluation of connectivity. This thesis covers the modelling of fracture networks, the characterisation (particularly connectivity) of fracture networks and applications.

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