Simulating fracture zone channel networks in groundwater models

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Summary

The presence and distribution of high transmissivity fracture zones in crystalline rock settings will strongly influence groundwater system behaviour. The properties of both the rock mass and fracture zones (including the presence of discrete flow channels or channel networks), such as hydraulic conductivity, can vary spatially over many orders of magnitude, having a profound influence on pore fluid velocities and solute transport times.

Methodology

A methodology is presented to generate channel networks within fracture zones. For this study, numerical groundwater models were used as a means to assemble, integrate and illustrate the role of geosphere parameters and properties. Spatially variable hydraulic conductivity fields are mapped onto the three-dimensional finite-element groundwater model mesh covering an area of approximately 153 km^2. Model boundaries were selected to correspond with surface water divides. The numerical groundwater modelling was performed using HydroGeoSphere, a dual continuum computational model that includes both porous media and discrete fracture zones. A discrete fracture zone network model, generated using MoFrac and delineated from surface features, was superimposed onto the three-dimensional mesh (see Figure 1).

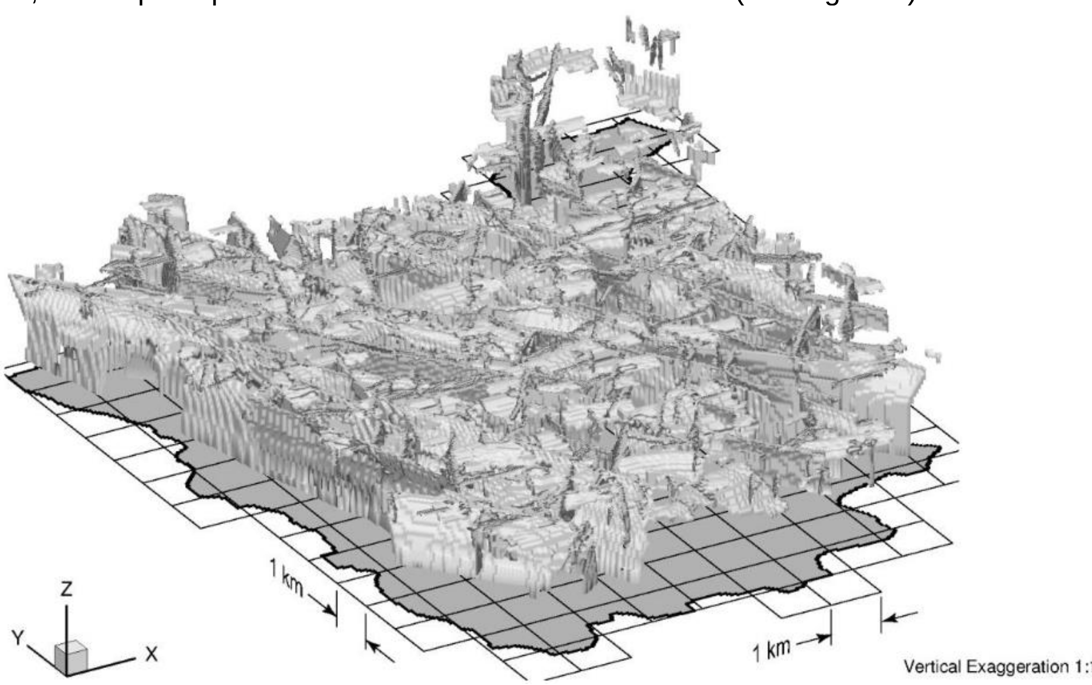

Figure 1: View of fracture zone network model mapped onto 3D groundwater model mesh.

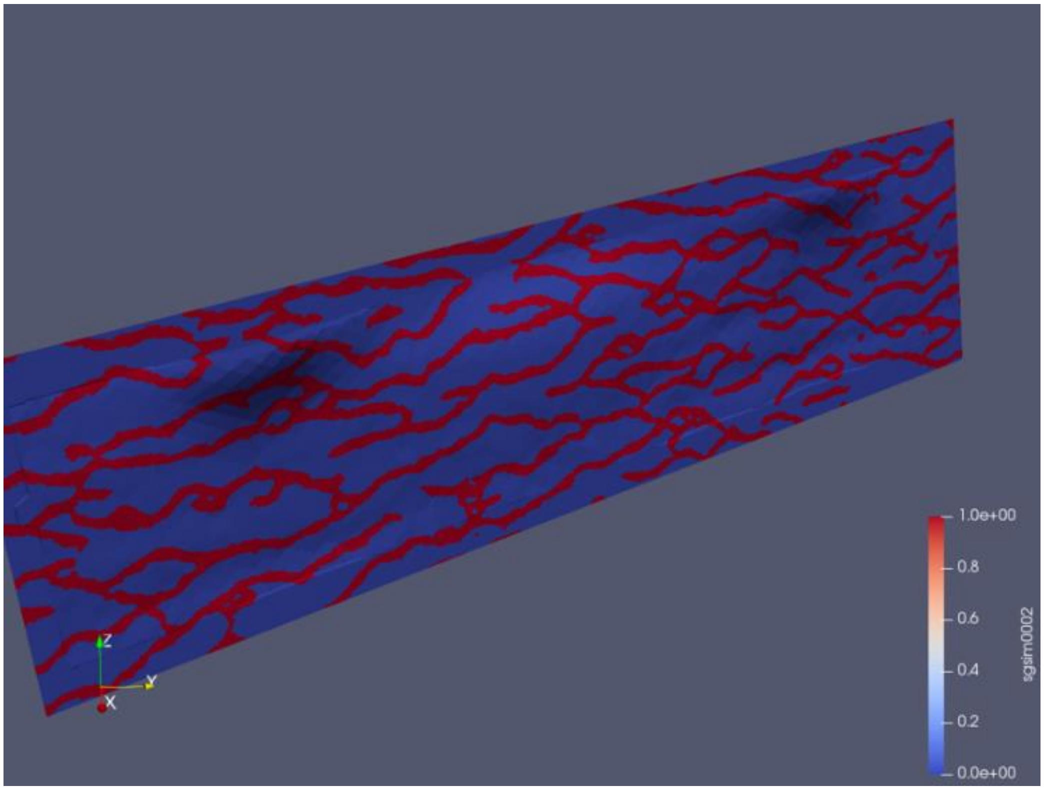

Figure 2: View of a simulated channel network within a single fracture zone.

The MoFrac code enables the generation of geostatistically and structurally possible fracture network models, and is capable of creating 3D discrete fracture network models at the tunnel, site and regional scale. Depth-dependent hydraulic conductivity distributions for both the equivalent porous media rock mass and fracture zones are implemented using statistics from Canadian Shield data. High permeability channel networks are generated and embedded within fracture zones (see Figure 2), and their impact on performance measures, such as the mean time to exit the groundwater system, is demonstrated using multiple equally likely realizations of the fracture zone channel networks.

Acknowledgements

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