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Stochastic simulation of fracture zone and rock mass properties in groundwater models

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Summary

Stochastic simulation is used to generate spatially variable properties for both the rock mass and the discrete fracture zones that intersect the rock mass in a crystalline rock. The presence and distribution of fracture zones in crystalline rock settings will strongly influence groundwater system behaviour. The properties of both the rock mass and fracture zones, such as hydraulic conductivity, can vary spatially over many orders of magnitude and have a profound influence on pore fluid velocities and solute transit times. Using data from the Canadian Shield, a methodology is presented to generate spatially variable, correlated, depth-dependent hydraulic conductivity fields for both rock mass and 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. The 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. 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. Spatially variable hydraulic conductivity distributions for both the rock mass and fracture zones are created using Sequential Gaussian Simulation (SGSIM) and transformed using statistics from the Canadian Shield data. Correlation lengths are applied using an exponential variogram. The impact of hydraulic conductivity spatial variability on performance measures, such as the mean time to exit the groundwater system, is demonstrated using multiple equally likely realizations of the rock mass and fracture zone hydraulic conductivity fields.