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Determination of hydraulic equivalents for layers of fractured sedimentary rock: Method and application to borehole data from the Hunter Valley, Australia

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Whether a fractured, especially multi-layered and multi-lithological, rock mass can be approximated by an equivalent continuum model has long been an important question for studies of fluid flow through this complex porous medium. Here we introduce a numerical procedure to evaluate the hydraulic equivalents, e.g., permeability tensor of fractured sedimentary rock layers, using a stochastic Representative Elementary Volume (REV) approach based on borehole data obtained during site investigations in the Hunter Valley, NSW, Australia Multiple realizations of stochastic, three-dimensional (3D) Discrete Fracture Network (DFN) models are generated, using Monte-Carlo simulations of fractured sedimentary rock layers, that are based on statistically derived fracture and lithological input data from borehole geological samples and geophysical logs. In order to determine an appropriate REV size, sub fracture systems with varying cubic model sizes, from 0.25^3 m^3 to 10^3 m^3, were extracted from the stochastically generated DFN models and evaluated for their equivalent permeability tensors. Results from the Monte-Carlo simulations corroborate that an REV exists and demonstrate that the variance of the calculated permeability values decreases significantly as the size of the extracted DFN model increases. Analysis shows that the coefficient of variation (the ratio of standard deviation over the mean value) of the diagonal permeability values decrease sharply from $\sim$180% to a levelling-off of $\sim$60% for all stochastically derived DFNs when sizes of cubic REVs increase from 0.25^3 m^3 to 10^3 m^3 in the simulated system.