Geophysical Research Abstracts, Vol. 8, 00044, 2006
SRef-ID: 1607-7962/gra/EGU06-A-00044

Prediction of Porous Medium Hydraulic Properties Based on Measured Air Permeability

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Knowledge of porous medium hydraulic properties is essential to understanding and predicting fluid flow in porous media. Although a number of methods exist to determine these properties, new and improved methods are always sought after. In this paper, we present a method to determine the pore size distribution of a consolidated sandstone rock core based on measured air permeability values as a function of water content. The theoretical part consists of two components: (1) the assumption of a capillary model, and (2) a genetic algorithm. The capillary model assumes a number of parallel pores, with each pore having sections of different diameters. The pore section diameters were assigned randomly based on a bimodal lognormal pore size distribution model. The assumed porous medium was initially water saturated. The pressure in the water was then gradually stepwise decreased. Application of the Young and Laplace equation allowed us to determine drainage of the pore sections. Once an entire pore section had drained, it could contribute to air flow across the porous medium. At each step (different water content), the air permeability value was calculated based on Poiseuille's law and the Darcy equation. These hypothetical values were then compared with the measured ones. The genetic algorithm was used to obtain the best possible fit between hypothetical and measured air permeability values by optimizing the assumed pore section diameters. The optimum pore size distribution was then used to calculate the water retention and hydraulic conductivity functions. The predicted hydraulic property values compared favorably with experimentally determined ones. The advantage of the genetic algorithm is that it considers a number of possible solutions simultaneously rather than just one, as is common with most other optimization schemes.