Geophysical Research Abstracts,
Vol. 10, EGU2008-A-09333, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-09333
EGU General Assembly 2008

Uncertainty and variability analysis of Discrete Fracture Network models from extensive outcrop and borehole field data.

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This study is part of an ongoing investigation conducted by the Swedish Nuclear Fuel and Waste management company, SKB, aimed at locating a repository for spent nuclear fuel. A key issue in the granitic studied sites is the presence of fractures. Their characterization is known as the Discrete Fracture Network model (DFN). The DFN is the critical link between field data interpretation and hydraulic predictions. Because it is obtained from limited sampling areas, such as outcrops or wells, the DFN contains both deterministic and statistical information. Deterministic information concern for example the position of some of the major fractures and statistical properties characterize in particular the fracture length and density distributions. Data are much too scarce to give an exact image of the natural fracture networks and too numerous to define directly a DFN. Data are thus both synthesized and extrapolated inducing respectively variability and uncertainty. Variability and uncertainty are fundamentally different in nature: variability means that fracture parameters vary for sure, but we cannot say where, while uncertainty means that the fracture density can vary but we cannot be sure it does. In stochastic simulations, variability can be treated as uncertainty or best as a stochastic function that stochastically ensure that fracture parameters vary through space.

The extensive database acquired on the Swedish sites allows a critical analysis of uncertainty and variability for the main DFN parameters that are the fracture length and density distributions. For the fracture length, the distribution obtained on outcrops is a power-law which exponent depends strongly on the mapped connectivity between fracture traces. We quantify the effect of fracture trace disconnections resulting from field mapping approximations and derive the subsequent uncertainty.

For the fracture density, we study the uncertainty/variability inclusion in the DFN models, based on borehole data coupled to deterministic/geological models. Fracture density is defined as a function of the fracture orientation (dip and strike). We set up a new methodology for identifying well segments having similar fracture densities. The principle is to gather the well segments into a restricted number of classes of width at least equal to the density data uncertainty. Uncertainty/variability naturally arises as the value dispersion within classes. We derive from the 1D density classes and the geologic observations a consistent 3D density model.

keywords: discrete fracture network, uncertainty, variability, fracture parameters.