Geological Processes to Consider for Modeling the Distribution of Hydrogeological Properties in Fractured Crystalline Rocks on a Site Scale

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Reliable predictions of the distribution of permeabilities on site scale are economically relevant in a wide range of geoscientific disciplines. Not only are predictions important for modeling hydrogeological conditions at site scale but also for using the underground safely and sustainably.

Scale dependent, different geological processes are influencing the distribution of hydrogeological properties. A dataset of about 5000 inflows from individual transmissive fractures draining to about 660 km of drifts and 57 km of boreholes has been compiled into depths of 2000 mbgs of the Variscan age German Ore Mountains (Erzgebirge/Krušné hory). Fracture closure with increasing depth is a main process controlling the distribution of transmissivities. Additionally, orientation, age and mode of fault zones exert a major control on the local distribution of inflows. These factors are locally overprinted by with the presence of contact metamorphic aureoles around Variscan granitic intrusions as seen from transmissivity reversals with depth. However, as seen from a decreasing trend of mean log hydraulic conductivity and permeability, the contact metamorphism exerts minor control on the rock mass hydrology with depth than the decreasing secondary porosity provided by fractures.

These findings are in accordance with results deduced from a worldwide permeability compilation of about 30000 single in-situ permeability measurements to depths of 2000 mbgs. Geological influences on the distribution have been analyzed on permeability-depth relationships using log-log regressions. Depth is generally the most important geological factor, resulting in a permeability decrease of three to four orders of magnitude in the investigated depth range. Beside depth, most influential factors are the long-term tectono-geological history described by geological province which locally is overprinted by current seismotectonic activity as determined by peak ground acceleration. Although petrography might be of local importance, only a low impact has been observed for the global dataset, besides lithologies allowing for karstification.

In summary, the multi-variate analysis of the datasets has improved our generic understanding of the distribution of hydrogeological properties and provides a basis to model hydrogeological processes in fractured crystalline rocks.