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Scale effects of hydraulic conductivity in karst and fractured aquifers

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General concepts of explaining a variation in hydraulic conductivity in karst and fractured rock systems with the scale of investigation are presented. For some fractured rock aquifer systems hydraulic conductivity increases with the measuring scale, decreases in other systems and in some areas no correlation can be observed. Emphasis is placed on explaining and measuring observed scale effects in karst groundwater systems.

Karst aquifers consist of highly conductive, low storage transit (conduits) and a low conductivity, high storage flow (fissured) system. Hydraulic parameters of karstified limestone aquifers are usually only available for individual boreholes not necessarily representative for the prediction of groundwater discharge and the assessment of water resources at catchment scale. The selection of the appropriate hydraulic parameters requires a careful analysis of the scale, the values are applicable at and the allocation of the parameters to the respective part of the system, characterised by an extreme contrast in hydraulic conductivity and storage.

Slug tests, injection, packer and pumping tests were used to obtain parameter estimates of the low and intermediate range of the hydraulic conductivity spectrum, which reflect the response of the aquifer at local scale. Regional parameters could be evaluated using several approaches. Applying Darcy and with the information on discharge and head gradient, spatial variation of average transmissivities can be calculated, representing the slow regional system. Taking the concept of Rorabaugh (1964) for flow from bank

storage, regional parameters were computed, using the recession coefficients for the fast and slow flow system. It could be observed that hydraulic conductivities generally increase with the scale of investigation which results from the added contribution to volume averaged hydraulic conductivity of highly conductive features at the respective scale.

In general, the various and also contrasting relationships between hydraulic conductivity and the scale of investigation found can be explained by the spatial organisation and the degree of networking of the drainage system.