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# Modelling solute transport in a fractured carbonate aquifer-type based on hydro-geophysical data

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Contaminants that are highly soluble in groundwater are rapidly transported via fractures and fissures in karstic aquifers. Hence, rigorous approaches are needed to model transport of soluble chemical species in such porous media. Here, we combine outcrop analysis of discontinuities and borehole hydro-geophysical testing to achieve a reliable groundwater and contaminant transport model. This workflow has been applied to the Permian Magnesian Limestone aquifer of Yorkshire (NE England, UK). Discontinuity surveys reveal much higher fracturing density in correspondence of extensional faults, as well as macro-porosity features created by faulting and dissolution.

Borehole fluid and televiewer logging, slug tests and hydraulic head monitoring have been used to calculate flowing porosity and flow velocities assuming a parallel plate model. Groundwater flow and fracture hydraulic aperture rapidly decrease with depth in the UK Magnesian Limestone. Thus, agricultural contaminants entering the aquifer with recharge water are laterally transported rapidly in the upper $\sim$ 20 meters. This finding has been incorporated in the groundwater flow model.

Computation of groundwater flow velocities allows determination of the Reynolds number. Values of up $\sim$1, indicating the lower limit of the transition from laminar to turbulent flow, are found at the studied site in non-faulted boreholes. Hence, turbulent flow is likely to arise in proximity to normal faults which are characterized by karstic cavities. As a consequence, turbulence has been represented in the groundwater flow model in correspondence of such tectonic structures. Modelling results show that solute contaminant transport in the UK Magnesian Limestone aquifer is primarily sensitive to values of effective flow porosity. Based on the site-scale study, we recommend a value of effective porosity of $2.5\times$10-4 for this aquifer type; note that this is some 10-2 times lower than those used in previous numerical models of solute transport in similar aquifers. The use of such a low value for fractured rocks is supported by recent hydro-geophysical data from other studies in North America. Following this research, we envisage further efforts on determination of effective flow porosity, which are typically overestimated by groundwater modellers.