The Effect of Matrix Diffusion on the Results of Large-Scale Tracer Experiment in a Fractured Dolomite

Kent Novakowski, Queen's University

At many industrial sites in eastern North America, aqueous phase contamination has pervaded the underlying bedrock. Where the bedrock consists of carbonate or sandstone stratigraphy, the potential for off-site migration is typically governed by the distribution of discrete fracture pathways and the degree to which contaminant mass might be lost to the matrix through diffusion. In many sedimentary rock settings it is assumed that there are abundant and parallel fracture pathways along bedding planes and that matrix diffusion may be limited over time as the matrix "fills up". To explore this, a tracer experiment was conducted in a flat-lying dolomite of Silurian age in which in-situ detection of tracer transport was used to identify specific pathways. The experiments were conducted over an extended period of time under a large forced gradient (radial injection) in order to investigate the effects of matrix diffusion in this setting. The experiment was conducted over the entire thickness (10 m) of one lithological unit utilizing a novel injection process which provided a radial source approximately 40 m in diameter. The arrival of a fluorescent tracer was detected in situ at a series of open monitoring wells located in the down gradient direction. The transport distances ranged from approximately 15 m to more than 200 m. The results show that an increasingly fewer number of fractures contributed to the transport pathway over increasing distance and that matrix diffusion dominated the transport in these features to the extent that almost all of the source mass was lost by the time the tracer reached the outermost monitoring wells. A discrete fracture numerical model (FRAC3DVS) was used to support this interpretation.

Kent Novakowski (PhD, Waterloo) is a Professor in the Department of Civil Engineering at Queen's University in Kingston, Ontario. Dr. Novakowski has more than 20 years experience in the characterisation and modelling of groundwater flow and contaminant transport in both crystalline and sedimentary fractured rock. He has published more than 145 papers and abstracts in a variety of proceedings and refereed journals. Dr. Novakowski is a past Associate Editor of Water Resources Research, the Journal of Contaminant Hydrology and the Journal of Groundwater, and has served as a consultant to various private companies and agencies in North America and abroad.