XVIII International Conference on Water Resources
CMWR 2010
J. Carrera (Ed)
CIMNE, Barcelona 2010

UPSCALING OF ADVECTIVE TRANSPORT IN A FRACTURED CLAY-RICH SEDIMENTARY FORMATION

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Summary. Clay-rich sediments appear to be suitable for deep geological storage of nuclear waste, mainly due to their low permeability and high retention capacity for cationic radionuclides. Performance assessment to test this hypothesis for specific sites relies heavily on numerical modeling of radionuclide transport. The need for Monte Carlo simulation and, subsequently, the costly coupling with chemical reactions make it impossible to run these simulations on the known local scale and upscaling is required. We look here at a generic fractured sedimentary host rock formation where the fracture permeability is on the order of the permeability of the matrix. The sediments are heterogeneous and characterized by large scale structures on the order of the domain size. Tools exist to upscale smaller scale heterogeneities and fracture networks in a nearly impermeable matrix, but it is still unclear how to upscale such a hybrid medium.

Our objective is to find an upscaling method for conservative, advective transport in a sedimentary, clay-rich, fractured formation dominated by large scale heterogeneities.

3D numerical simulations are performed at the local scale of a sedimentary host rock dominated by some clay-rich background strata and a single more conductive continuous layer consisting mainly of fractured limestone. Both units are internally highly heterogeneous with correlation lengths on the order of the domain size. The fine scale grid consists of about 15 million nodes. The 3 fracture systems are generated stochastically and are adjusted to match the regular grid of the matrix. We then gradually upscale the hydraulic conductivity field block-wise, conserving total flux through the domain, and perform particle tracking ignoring local dispersion. We compare the results in terms of travel time and spatial deviation of the particle location relative to the mean flow direction after passing through the domain. Then we reproduce the local scale results for the different block sizes using the proposed upscaling methods.

For upscaling of the sediments only we find that for smaller blocks the use of an advection-dispersion type equation appears still reasonable. But for larger blocks a multi-porosity model becomes necessary. These large blocks become particularly important if field scale reactive transport is simulated. Preliminary results of simulating transport in the hybrid matrix-fracture domain indicated that multi-porosity models are already needed for the smaller blocks.