Multi-Scale Method for Up-Scaling Transport in Hierarchical Porous Media

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ABSTRACT: Natural compacted clays have remarkably low hydraulic conductivity and are therefore suitable for backfill and protective barriers in radioactive waste disposal sites. To assess the long-term migration of radionuclides, macroscopic models for the transport are employed. Effective parameters in these models are obtained by up-scaling molecular transport properties of radionuclides over a representative sample of the clay medium. For the purpose of numerical up-scaling, we have developed a computer strategy to generate pore maps of clay micro-structures, which have pores at two different scales (macro and micro). A direct application of the homogenization technique to obtain effective transport parameters, e.g. effective diffusion coefficient, would be time consuming, if on a pore map both macro- and micro- pores were to be represented simultaneously. To reduce the computational effort (significantly), however, without compromising on the accuracy of the up-scaled results, we propose a multi-scale solution strategy in which the original fine-scale problem is decomposed into a global problem within all connected macro-pores and several local problems in micro-pores. Not only this decomposition allows one to choose different resolutions in macro- and micro- pores, dealing with the resulting system is computationally much inexpensive. The presented numerical results show an excellent agreement between the original fine-scale solution and the corresponding multi-scale solution.