Geophysical Research Abstracts
Vol. 14, EGU2012-4009, 2012
EGU General Assembly 2012

Modelling migration and dissolution of mineral particles in saturated porous media

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Understanding and predicting the fate in soils and other porous media of solid mineral particles with grain diameters in the micrometer range is important in a number of environmental and civil engineering applications, including subsurface hydrology, wastewater treatment and oil/gas production. In this context, deep-bed filtration theory is commonly applied to model particle detachment and deposition. Most existing models however neglect some processes that can modify groundwater flow patterns, particle concentration and attachment/detachment coefficients.

The aim of this work was to develop a mechanistic model to study the transport and mobilization/immobilization of mineral particles in saturated porous media. The model accounts for particle advection and dispersion, deep-bed filtration, porosity and hydraulic conductivity changes associated with deposition and mobilization, and for particle dissolution. In addition, the deep-bed filtration coefficients vary with the characteristics and composition of the pore-solution, ionic strength and pH in particular. The groundwater flow and reactive transport simulator PHAST was used to implement the model.

Measurements from a variety of deep-bed filtration and mineral dissolution experiments were used to calibrate and validate the model. A satisfactory comparison was found in most situations. A sensitivity analysis was subsequently performed to identify the conditions in which some of the processes (such as hydraulic conductivity changes and particle dissolution) can be neglected and therefore less sophisticated numerical tools can be used.