Geophysical Research Abstracts,
Vol. 11, EGU2009-487, 2009
EGU General Assembly 2009

Numerical and experimental study of density flow in porous media

M. Konz (1), Ph. Ackerer (2), A. Younes (2), P. Huggenberger (1), and E. Zechner (1)

(1) University of Basel, Applied and Environmental Geology Group, Switzerland (m.konz@gmx.de), (2) Université Louis Pasteur, Institut de Mécanique des Fluides et des Solides, CNRS, UMR 7507, Strasbourg, France

In order to investigate the influence of density effects on flow and transport processes and to provide data sets to test numerical codes, series of 2D laboratory scale porous media tank experiments (158 cm x 98 cm x 4 cm) were completed. The experiments were conducted in flow tanks with a homogeneous, a complex geometrical, and a heterogeneous setup. The complex geometrical setup was constructed with an impermeable layer made of Plexiglas that divides the flow domain into two regions connected by a 5 cm wide channel. The impermeable layer within the porous medium forced the solutes to pass through a vertical channel, representing a geological fault zone, to reach the outlet of the tank. The heterogeneous porous medium was constructed of two different glass beads with the fine beads forming a block in the centre of the tank.

Considerable instabilities, manifested in finger development along vertical density gradients, could be observed at the horizontal interface of fine and coarse beads in the heterogeneous experimental setup. A comparison of simulation results from tracer and heterogeneous variable-density flow experiments with identical boundary conditions have shown that the assumption of non-Fickian dispersivity is valid for experiments with high density contrasts in heterogeneous porous media. Simulations of the variable-density flow experiments required a reduction of the longitudinal dispersivity of up to ten times compared to the tracer experiment. Besides the non-Fickian flow, fingering is a considerable mass transport process, and has to be considered in the heterogeneous experiments. Blocks with an average permeability had to be introduced at the interface of the coarse and fine beads zones in order to initialize a perturbation of the flow field. The average permeability was calculated from the fine and coarse beads zones' permeability. This improved the simulation of the instable transport phenomena.

A numerical model based on Mixed Finite Elements for the fluid flow problem and a combination of Discontinuous Galerkin Finite Element and Multi-Point Flux Approximation methods for the transport turned out to be adequate for the simulation of the physical experiments. The numerical results along with the experimental data are presented as benchmark problems to evaluate density flow codes. The high data availability makes the proposed benchmark experiments a valuable tool for assessing the performance of density-coupled flow models. The complex geometrical experiment has shown that the salt distribution above the impermeable layer differs significantly from the tracer distribution and a larger part of the aquifer is affected by the saltwater. Further, higher salt concentrations can be expected at the bottom of the upper aquifer. Therefore, the visualization of the experimental plume patterns gives a better idea of the requirements of an effective regional-scale groundwater monitoring system.