Benchmark calculations of variable-density flow in porous media

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Abstract

Variable-density porous media flow problem is coupled problem of water flow and solute transport: the water velocity as a result of the flow problem is a parameter in the solute transport problem (standard case) and the solution density as a parameter in the flow problem is dependent on concentration, result of the transport problem (specific for variable-density flow) [1].

We present results of numerical simulations of a particular benchmark problem, comparing the density-coupled model with the uncoupled one, two different finite-element approximations below, influence of discretisation size, and influence of physical parameters (intensity of coupling).

The 3D discretisation mesh is composed of trilateral prismatic elements and derived from unstructured triangulation in the horizontal projection. The numerical approaches used in the calculations are the following:

1. The flow problem is solved with combination of standard finite element method with linear base function in 2D and separate vertical discretisation, allowing to express conservative fluxes between the nodes [3]. The transport problem is solved by finite volume method on "dual" mesh of control volumes associated with finite-element nodes.
2. The flow problem is solved with mixed-hybrid finite elements (lowest order Raviart-Thomas space for velocity unknowns) and the transport problem with finite volumes on the original prismatic elements.

Like e.g. the saltdome problem [1], the studied benchmark problem compare the antagonistic forces on the contamination movement: the piezometric gradient upwards and the gravity (density effect) downwards. The problem is based on a real hydrogeological configuration in Stráž pod Ralskem in the northern Bohemia [2].

The numerical results confirm the strong influence of physical parameters and vertical discretisation. The difference between both studied numerical methods is smaller.

References

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