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A solution scheme for simulating of tracer transport in a non-isothermal two-phase flow system

F. Tong, A. Niemi, Z. Yang, and F. Fagerlund
Department of Earth Sciences, Uppsala University, Villavägen 16, 75236 Uppsala, Sweden (fuguo.tong@geo.uu.se)

As part of the EU FP7 MUSTANG project, different types of tracers arre being developed and tested, specifically for the purpose of characterization of geologically stored CO_2 and its phase partitioning and migration in deep saline formations. In order to correctly interpret the tracer signals, a new mathematical model for tracer transport in non-isothermal two-phase flow system has been developed. The model includes five different differential equations describing liquid-phase flow, gas flow, heat transport and the movement of the tracers within the two phases, as well as allows kinetic transport of the tracers between the two phases. The latter is a feature not usually available in codes used for CO_2 storage simulation and therefore the motivation for the code development. Due to the highly non-linear nature of the equations to be solved, special demands are placed to the solution scheme.

This paper presents a solution scheme as applied to tracer transport in a non-isothermal two-phase flow system, including discussion on the discretization method, iterative routine and solution strategies. Temperature, gas pressure, degree of liquid saturation and concentration of tracers in liquid and gas phases were chosen as the five primary variables. In order to improve the convergence of the solution, the total mass conservation equation is used for calculating gas pressure. For improved numerical stability, the degree of liquid saturation was calculated by gas flow equation, instead of liquid-phase flow equation. A special weighting function is adopted in the solution of two-phase flow to cancel any non-physical oscillations and a special method was developed for avoiding spurious oscillation, numerical dispersion and phase error in the solution of tracer transport. The presentation shows validation of the model results against existing numerical and analytical solutions and demonstrations for time dependent (kinetic) tracer transfer between the phases. Furthermore, numerical tests show the capability of the scheme to achieve convergence, to add to numerical stability and to cancel no-physical oscillations.