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Numerical simulations of the anomalous solute transport in a fractured porous aquifer

Chiba R., Okaze T., Fomin S., Chugunov V., Niibori Y., Fukunaga H., Hashida T.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

A computer program, which enables us to calculate the anomalous non-Fickian contaminant transport in complex medium, has been developed. In recent years, prediction of mass transport in fractured porous media is becoming increasingly more important for the development of subsurface energy and material systems such as geothermal energy system and the geological disposal of radioactive wastes. Solute transport simulation can serve as an effective tool for predicting subsurface fluid flow but requires accurate model derivation and reliable values of physical parameters. The conventional mathematical model of contaminant transport in the aquifer is based on the Fick's law of diffusion. However, for the fractured porous media, where solute moves primarily through open channels and slowly diffuses into the porous blocks, the conventional model tends to predict smaller solute travel distance than that in the actual transport process. In contrast, the non-Fickian diffusion model can provide realistic representation of actual fluid flow in the heterogeneous media, such as fractured porous rocks. In the non-Fickian diffusion model, the governing equation is written in terms of fractional derivatives. In this study, in order to expand the applicability of the non-Fickian diffusion model to a variety of practical engineering problems, a numerical method has been developed. We provide a numerical solution of the equations by using implicit-finite difference method. The results obtained by numerical solution of the fractional differential equations were shown to be in a good agreement with analytical solutions.

Keywords

Anomalous contaminant transport, Fractional derivative, Fractured porous media, Non-Fickian diffusion