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Finite volume approximation of a diffusion–dissolution model and application to nuclear waste storage☆

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Abstract

The study of two phase flow in porous media under high capillary pressures, in the case where one phase is incompressible and the other phase is gaseous, shows complex phenomena. We present in this paper a numerical approximation method, based on a two pressures formulation in the case where both phases are miscible, which is shown to also handle the limit case of immiscible phases. The space discretization is performed using a finite volume method, which can handle general grids. The efficiency of the formulation is shown on three numerical examples related to underground waste disposal situations.

Keywords: Two phase Darcy flow in porous media; Finite volume method; Nuclear waste storage

1. Introduction

A large community of scientists is concerned with understanding the mechanical and hydraulic behaviour of deep repository radioactive waste, in reason of its large impact on environment and human safety. This implies to be able to model and simulate complex phenomena such as the de-saturation and re-saturation of geological media, gas production induced by the corrosion of steel containers, within complex 3D heterogeneous and anisotropic domains including singular zones such as galleries and cells intersections. Moreover, materials with highly contrasted physical properties are involved in long time phenomena (from thousand to millions of years).

Hence the simulation of these physical features happens to be a complex task, and their validation is a major concern for the safety improvement of the industrial devices. Computational benchmarks, such as the Couplex Gaz benchmark [18], are useful for the definition of relevant physical models and numerical methods. Indeed, the Couplex Gaz benchmark has shown that the Darcy flow of two immiscible phases, the first one being an incompressible liquid phase and the second one the gaseous phase, can lead, in presence of high capillary pressures, to unphysical situations and to drastic numerical difficulties. This model implies the displacement of a free boundary between zones where the

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