



HAL
open science

Numerical modeling of coupled two-phase multicomponent flow with reactive geochemical transport in porous media

Etienne Ahusborde, Brahim Amaziane, Mustapha El Ossmani, Philippe
Poncet

► **To cite this version:**

Etienne Ahusborde, Brahim Amaziane, Mustapha El Ossmani, Philippe Poncet. Numerical modeling of coupled two-phase multicomponent flow with reactive geochemical transport in porous media. 13èmes Journées d'études des Milieux Poreux 2016, Oct 2016, Anglet, France. hal-01394471

HAL Id: hal-01394471

<https://hal.science/hal-01394471>

Submitted on 9 Nov 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Numerical modeling of coupled two-phase multicomponent flow with reactive geochemical transport in porous media

E. Ahusborde^a, B. Amaziane^a, M. El Ossmani^a, Ph. Poncet^a

^a*LMAP, UMR CNRS 5142, Université de Pau et des Pays de l'Adour, France.*

Keywords: Two-phase multicomponent flow, Reactive transport, Code coupling, DuMu^X

1. Introduction

In this talk, we will discuss a new numerical modelling of two-phase multicomponent flow with reactive transport in porous media such as immiscible gas injection in oil reservoirs, gas migration in a nuclear waste repository or long-term fate of injected CO₂ for geological sequestration [1].

We will focus on the numerical modelling of immiscible compressible two-phase flow in porous media with geochemistry. The problem is modelled by the mass balance law for each phase, Darcy-Muskat's law, the capillary pressure law and the coupling with chemistry occurs through reactions rates. In the case of kinetic reactions, these rates are nonlinear functions of the concentrations involved in ordinary differential equations, while for equilibrium reactions, these rates are unknown and replaced by the mass action laws that relate the activities of concerned species.

2. Methodology

A sequential approach solving firstly a two-phase flow model and then the reactive transport problem, has been implemented in the open-source simulator DuMu^X [2]. This strategy is schematised in Figure 1:

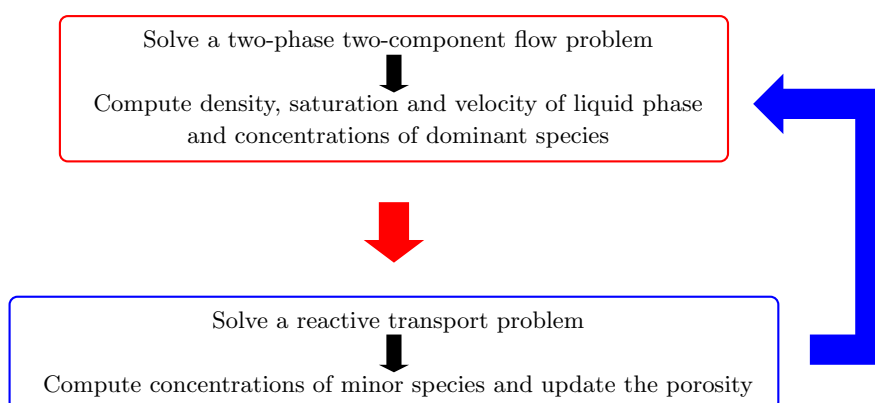


Figure 1: Coupling procedure between flow and reactive transport modules.

- Firstly, the module 2p2c, based on an implicit finite volume method, is used to solve a two-phase two-component flow model considering that a dominant component exists in each phase. The concentration of other species, assumed as minor, are treated explicitly.
- Secondly, a direct substitution approach is employed to obtain the reactive transport system described by advection dispersion reaction equations coupled to differential algebraic equations to deal with the minor species. Again an implicit finite volume method is used to discretize this system. A new reactive transport module called 1pNc-react was implemented in DuMu^X.

Finally, an efficient coupling between the modules 2p2c and 1pNc-react has been developed. The accuracy and effectiveness of this new simulator is demonstrated through numerical investigation.

3. Numerical results

To validate our methodology, we have performed a test case proposed in [3]. The domain is three-dimensional and a pure CO_2 steam is injected in a well located 25m from the top of the aquifer. The chemical system consists of 12 components involved in 3 equilibrium reactions and 3 kinetic reactions. Injection is performed during 20 years while time of simulation equals 2000 years. The model contains 10000 grid blocks.

Figure 2 displays concentration of calcite and anorthite at $t = 2000$ years. Initially, their concentration were respectively 238 and 87 mol.m^{-3} . We can see that calcite is dissolved near the injection of CO_2 and precipitated far from the injection while anorthite is dissolved everywhere. The molality of aqueous CO_2 and the pH are also depicted. They are strongly correlated since high concentration of aqueous CO_2 acidifies the liquid phase.

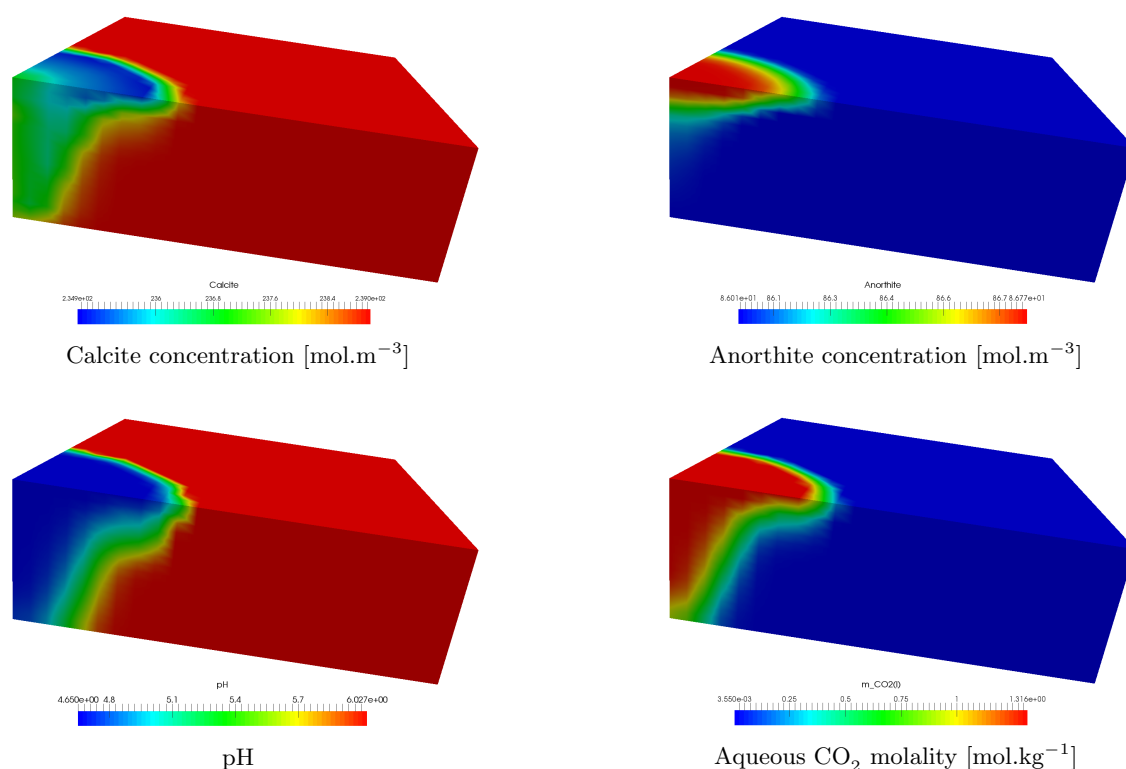


Figure 2: Profiles at $t = 2000$ years.

References

- [1] F. Zhang, G. Yeh, J. Parker (Eds.), *Groundwater reactive transport models*. Bentham e-books, 2012.
- [2] B. Flemisch, M. Darcis, K. Erbertseder, B. Faigle, A. Lauser, K. Mosthaf, S. M. S., P. Nuske, A. Tatomir, M. Wolf, R. Helmig, DuMu^X: DUNE for multi-{Phase, Component, Scale, Physics, ...} flow and transport in porous media, *Advances in Water Resources*, 34, 1102–1112 (2011).
- [3] Y. Fan, L. J. Durlofsky, H. A. Tchelepi, A fully-coupled flow-reactive-transport formulation based on element conservation with application to CO_2 storage simulations., *Advances in Water Resources*, 42, 47–61, (2012).