InterPore2021
Online
13th Annual Meeting
31 May - 4 June 2021
Don't miss a moment!
Plan to view presentations before the conference

Contribution ID: **266** Type: **Oral Presentation**

A Stochastic Particle-Based Framework for Multiphase Flows in Fractured Porous Media

Wednesday, 2 June 2021 14:15 (15 minutes)

In the context of two-phase flows in porous media, Tyagi and Jenny (2008) have discussed the potential of particle-based schemes to simulate macroscale transport using the information of microscale flow dynamics. However, with the uncertainties in heterogeneity characterization and additionally, modeling challenges, obtaining a well-informed picture of microscale dynamics is not feasible. Instead, a probabilistic description can be used which focuses on the Lagrangian evolution of fluid elements and the properties associated with them, e.g., scalar concentration [Tyagi and Jenny (2011)].

In probability density function (PDF) methods, for example, computational (stochastic) particles, characterized by their position and properties, are used. Particles evolve as per stochastic processes which are defined such that the computational particles and fluid elements are statistically equivalent [Pope (1985)]. We devise a stochastic particle framework that simulates multi-phase, multi-species transport in a fractured porous media with a permeable matrix.

We adopt an Embedded Discrete Fracture Model (EDFM) where the discretization of the matrix is independent of the fracture geometry, and the fractures are treated as lower dimensional manifolds [Hajibeygi et al. (2011), Deb et al. (2017)]. The flexibility of using a structured grid for the matrix makes EDFMs better suited for particle-based transport models. The matrix-fracture interfaces are not resolved within the grid-cells, which motives a probabilistic description of particle transfer between the matrix and the fractures.

In Monga et al. (2020), we presented a conservative stochastic particle-tracking scheme for advective, single phase solute transport in fractured reservoirs. This scheme uses a continuous time Markov process for inter-continuum exchange, characterized by particle transfer probabilities. These probabilities depend on the particle pathline and scale with the particle's time to traverse a grid cell.

The focus of the current work is to extend the above stochastic particle scheme to model saturation evolution in a multi-phase immiscible flow. Similar to Tyagi et al. (2008), particles propagate in the physical (and property) space(s). Macroscale quantities like the saturation are defined by particle ensembles (over finite volumes). In our work, a particle has an additional attribute, i.e., its continuum state, and the transfer probabilities govern its evolution. The ensemble-derived flux is consistent with the macroscale laws for the average flux given by, e.g., Darcy's law and flux functions for fluid exchange between continua.

The hyperbolic nature of non-linear saturation transport and a finite ensemble size pose a challenge for particle methods, mainly in terms of capturing saturation discontinuities. We tackle this by adding minimal dispersion to the transport.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

1. Tyagi, M., Jenny, P., Lunati, I., & Tchelepi, H. A. (2008). A Lagrangian, stochastic modeling framework for multi-phase flow in porous media. Journal of Computational Physics, 227(13), 6696-6714.

2. Tyagi, M., & Jenny, P. (2011). Probability density function modeling of multi-phase flow in porous media with density-driven gravity currents. Transport in porous media, 87(2), 603-623.
3. Pope, S. B. (1985). PDF methods for turbulent reactive flows. Progress in energy and combustion science, 11(2), 119-192.
4. Deb, R., & Jenny, P. (2017). Finite volume–based modeling of flow-induced shear failure along fracture manifolds. International Journal for Numerical and Analytical Methods in Geomechanics, 41(18), 1922-1942.
5. Hajibeygi, H., Karvounis, D., & Jenny, P. (2011). A hierarchical fracture model for the iterative multiscale finite volume method. Journal of Computational Physics, 230(24), 8729-8743.
6. Monga, R., Deb, R., Meyer, D. W., & Jenny, P. (2020, September). Particle Transport Scheme for Embedded Discrete Fracture Models. In ECMOR XVII (Vol. 2020, No. 1, pp. 1-15). European Association of Geoscientists & Engineers.

Acceptance of Terms and Conditions

Click here to agree

Newsletter

Student Poster Award

Primary authors: Mr MONGA, Ranit (Institute of Fluid Dynamics, ETH Zürich); MEYER, Daniel W. (Institute of Fluid Dynamics, ETH Zurich); JENNY, Patrick (Institute of Fluid Dynamics, ETH Zürich)

Presenter: Mr MONGA, Ranit (Institute of Fluid Dynamics, ETH Zürich)

Session Classification: MS3

Track Classification: (MS3) Flow, transport and mechanics in fractured porous media