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Numerical simulation of kinetic interface sensitive tracers in two-phase flow in porous media applied in two-dimensional experimental setups

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The newly developed kinetic interface sensitive (KIS) tracers have been the focus of research in the past decade, as a new method to determine the mobile interfacial area between immiscible fluids in porous media. An accurate and reliable interfacial area determination is crucial to several industrial applications and the geoscientific research.

In this work we investigate the relationship between the concentration breakthrough curves of the KIS tracer, consequently the specific interfacial area and the evolution of the mobile non-wetting-phase front.

Up to now, such laboratory experiments have been conducted only in columns, quasi-one-dimensional systems. In this study we consider two-dimensional domains filled with porous material where immiscible displacement of water by oil takes place. The presence of heterogenous inclusions leads to perturbations in the fluid interface and causes fingers. By means of numerical modelling we investigate these effects and the results will help as a basis in the design of a new two-dimensional flume setup.

An analysis is performed for different viscosity ratios, capillary numbers corresponding to different capillary pressure-saturation relationships, injection rates and geometrical heterogeneity. We found that the presence of higher or lower permeability inclusions have a significant but clearly distinct impact on the destruction and/or production of the fluid-fluid interfacial area. Lower permeability inclusions increase the overall area of the front, compared to a decrease in the overall area for higher permeability inclusions. By increasing the interfacial area an increase of the reactive tracer concentration is observed. The mobile interfacial area is evaluated at the front of the saturation profile by using a cut-off value from the saturation profile, and then the area of the mobile concentration of the reactive tracer is calculated.