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Non-linear interactions of dynamic reactive interfaces in hydrothermal porous media

Qiangqiang Liu
School of Mechanical and Chemical Engineering, The University of Western Australia, Crawley, Australia

The transport of solutes and heat through porous media and the modification of porous media by reactive fluids are important areas of research in the mineralization process of Earth science.The patterns and nonlinear dynamics of miscible viscous fingering are investigated numerically for an A+B->C type of reactive system in homogeneous hydrothermal porous media. The effect of heat is considered in the development of a spatiotemporal distribution of the reaction-diffusion-convection (RDC) process. The dependence of viscosity of the fluid on the temperature and concentration of product C is assumed to be exponential, respectively represented by thermal mobility ratio β_τ and solute mobility ratio β_C. The physical and chemical front, viscously stable or not, also depends on other parameters such as Lewis number Le, thermal lag coefficient λ and Damkohler number Da. The continuity equation, Darcy's Law, and convection-diffusion-reaction equations for mass and heat balance are used to nonlinearly simulate the chemically and thermally driven finger-like frontal deformation between the contact area of reactants A and B, depending on the different scenarios of those parameters. It is found that an increase in the thermal mobility ratio and Damkohler number will enhance the hydrodynamic instability, while a decrease in the thermal lag coefficient and an increase in the Lewis number always decrease the instability. Normally heat diffuses at a greater rate than that of mass, corresponding to Le > > 1, which causes a double diffusive effect and therefore changes the dynamics of the RDC process. For large Lewis number, the instability is seen to be strictly dominated by the solute mobility ratio. When the thermal lag coefficient equals to 1, less complex finger patterns are observed than in a reference isothermal case with the same solute mobility ratio but with a zero thermal mobility ratio. As the thermal lag coefficient is decreased, a highly diffusive thermal front lags further behind the fluid front and the stabilizing effect of strong thermal diffusion gets alleviated. For larger Da, it was found that the effect of shielding was suppressed, and hence the fingering pattern became denser within a given area.