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Effects of mechanical dispersion on the morphological evolution of the reaction front during transport in a homogeneous porous medium with initial small non-uniformities

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The morphological evolution of a chemical dissolution front is an important topic in geological processes and engineering practices. Although previous studies have extensively presented a number of numerical models which couples a system of nonlinear governing equations of porosity change due to mineral dissolution, the conservations of groundwater flow and transport of chemical species to investigate the morphological pattern of a chemical dissolution front within a fluid-saturated porous medium, whereas the mechanical dispersion effect has generally been neglected in the model development. This study addresses the effects of mechanical dispersion on the morphological evolution of a chemical dissolution front for a variety of cases. Mechanical dispersion processes is incorporated with the coupled nonlinear governing equation system so as to rebuild a newly numerical model. The results of numerical simulations demonstrate that mechanical dispersion has pronounced impacts on the morphological pattern of the chemical dissolution front. For single local non-uniformity case, mechanical dispersion reduces the finger length of an unstable single-fingering front or retains the shape of a stable planar front while speeding up the front advancement. In the case of two local non-uniformities, adding mechanical dispersion with different flow conditions can yield one of the following results: (1) the shape of the stable planar front is maintained but its advancement is accelerated; (2) the shape of the unstable single-fingering front is maintained but its length is reduced; (3) the unstable double-fingering front is merged into an unstable single-fingering front; and (4) the shape of the unstable double-fingering front is preserved but its fingering length is reduced.. A comparison between the behavior diagrams of dissolution front morphology (with and without considering mechanical dispersion) shows that the double-fingering front occurs under condition where the upstream pressure gradient is higher and the non-uniformity spacing is larger while mechanical dispersion is taken into consideration.