Dispersive effects in buoyancy-driven flow including plume-fed gravity currents

Buoyancy-driven flow in porous media is bookended by two canonical scenarios: a vertically-descending plume and horizontally-propagating gravity current. Whereas the former is dominated by entrainment, the latter often includes significant dispersion. For example, when a gravity current propagates down-dip along a permeability jump (sloping or horizontal), the leading edge may fractionate into bulk and dispersed interfaces. Sahu and Neufeld (J. Fluid Mech., Vol. 886 ,2020) studied dispersive effects and gravity current flow both theoretically and experimentally. They considered dispersive effects only in the transverse direction and not in the longitudinal direction. Aiming to expand upon their pioneering study, we wish to investigate dispersive effects both parallel and perpendicular to the principle direction of flow. To this end, we developed a COMSOL model to study miscible buoyancy-driven flows in porous media in which different categories of flow arise. These categories include plume flow, gravity current flow and drainage from an upper layer of high permeability to a lower layer of low permeability. Our model is validated by comparing the numerical results with existing experimental data. We exploit this model to study the effects of dispersive entrainment in directions both perpendicular and parallel to the flow.

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