# Modelling mesoscale multiphase interactions using modified smoothed particle hydrodynamics

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## Abstract

The complex multiphysics and multiphase interactions involved in the subsurface underpin the performance of diverse energy systems including $CO_2$ geo-sequestration, production of unconventional oil and gas, and generation of enhanced geothermal energy. For example, the $CO_2$–brine–silica interaction in saline aquifer and the gas–water–rock interaction in hydraulically fractured shale gas reservoirs both involve complex multiphase interactions at the mesoscale. In this study, a modified smoothed particle hydrodynamics (SPH) is developed to model multiphase interactions at the mesoscale. Using an inter-particle force formulation that mimics the inter-atomic force in molecular dynamics, the modified SPH framework includes the long-range attractions between particles, and more importantly, the short-range repulsive forces to avoid particle clustering and instability problems. The proposed SPH framework is able to not only take the surface tension effect into consideration when simulating multiphase flow, but also explicitly model the solid deformation induced by fluid–solid interaction. In this paper, various simulation results will be presented to demonstrate the capability of the proposed SPH framework to genuinely model complex multiphase interactions in partially saturated porous media at the mesoscale.

**Keywords**: Smoothed particle hydrodynamics, surface tension, contact angle, inter-particle force, multiphase interaction