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Modeling of micro-particle transport in supercritical CO2 over rough fractures

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SC-CO2 (supercritical carbon dioxide) has attracted much attention in subsurface engineering process, such as CO2 sequestration, enhanced oil recovery and geothermal development. Using micro-particle as proppant in SC-CO2 fracturing is a new fracturing technology in unconventional oil and gas reservoirs. Despite the multiphase flow of SC-CO2 in porous media has been widely studied in recent years, the transport of micro-particles in SC-CO2 over fractures still need further research.

In this study, a coupled computational fluid dynamics and discrete element method (CFD–DEM) approach is used to study the transport behavior of micro-particles with SC-CO2 over rough natural fractures. Rough fracture geometries are generated with the geostatistical simulator Synfrac. The difference in the particle transport characteristics between SC-CO2 and slick-water are demonstrated. The effects of fluid properties, particle parameters, and fracture morphology on micro-particle carrying behaviors in rough fractures were discussed. Results show that particle-carrying performance depends on fluid viscosity and flow rate. Larger critical settling velocity of particles in low viscosity SC-CO2 leads to the formation of sand dune at the bottom of fractures. Micro-particles are prone to form a multi-layer's sand dune with high particle concentration. Also, the presence of vortices in SC-CO2 around a rough fracture surface leads to the suspension of micro-particles, particularly when the flow field is subjected to high injection rate and high Reynolds number. This ultimately results in a wider distribution of micro-particles in SC-CO2 within the fracture compared to water. Due to the particle accumulations on the sand bed surface, fracture apertures is reduced and leads to fast flow velocity. The turbulent flow regions of CO2 fluids are generated. In the vicinity of high Reynolds flow regime, the flow field enhances the suspension capacity of particles. Turbulent flow at fracture junctions helps to deliver particles into deeper and farther of natural fractures in low viscosity SC-CO2 fluids by disturbing the movement of sand dune. The overall findings provide a greater understanding of transport behaviors of micro-particle with SC-CO2 over rough fractures underground.

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Primary authors: ZHOU, Qianqian; WANG, Bin (China University of Petroleum - Beijing); Prof. WANG, Haizhu; Prof. ZHOU, Mengmeng; Mr YANG, Zhichao; Dr ZHENG, Yong

Presenter: ZHOU, Qianqian

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