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Wettability Impact on Immiscible Fluids Flow in Rough Fracture

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Wettability can dramatically impact on the immiscible fluids flow in permeable media, including subsurface technologies to microfluidics. Previous studies have profoundly revealed this effect on flow in porous media, but so far, few systematic results on how the wettability controls flow in rough fracture are reported. Here, we conduct the visualization experiment to investigate the immiscible fluid-fluid displacement, by systematically varying the wettability of the fracture cell over a wide range of contact angles. Our observation shows that increasing the fracture's affinity to the invading fluid results in more efficient displacement of the defending fluid up to a critical wetting transition, beyond which the trend is reversed. We find this critical contact angle is related to the roughed-wall geometry. We derive a theoretical model that describes the transitions of displacement patterns from capillary imbibition to capillary fingering to the crossover to viscous fingering as functions of wettability. This work draws the phase diagram considering wettability in rock fracture and is of practical significance in subsurface applications.

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Primary author: Dr WU, dongsheng (CHENGDU UNIVERSITY OF TECHNOLOGY)

Co-authors: Mr DENG, Han-Xing (CHENGDU UNIVERSITY OF TECHNOLOGY); Dr WANG, Xiao-Guang (CHENGDU UNIVERSITY OF TECHNOLOGY); Dr WANG, Dong-Po (CHENGDU UNIVERSITY OF TECHNOLOGY)

Presenter: Dr WU, dongsheng (CHENGDU UNIVERSITY OF TECHNOLOGY)

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