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Bypass flow of trapped droplet under seismic stimulations through pore double model analysis

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The study of trapping and releasing nonwetting droplets in porous materials has been extensively explored. However, dynamically characterizing residual nonwetting droplets under vibrations within porous media remains a challenging endeavor. Current theoretical models addressing seismic responses in two-phase flow primarily focus on single-channel geometries with fixed pressure differentials across inlet and outlet boundaries. In practical porous media, trapped droplets exist amidst flowing aqueous phases. External vibrations can induce significant pressure fluctuations due to surrounding flows, making the fixed pressure differential assumption invalid in a single-channel model. To overcome these constraints, this study delves into the micro-scale dynamics, aiming to surpass the limitations of the single-channel model. A theoretical framework involving a pore doublet, i.e., a sinusoidally constricted channel paralleled with a straight channel, is proposed to account for bypass flow effects. Initially, we analyze alterations in pressure differentials upstream and downstream of residual nonwetting droplets, considering flow dynamics during seismic excitation. We evaluate the impact of these pressure differential variations on predictive accuracy compared to the fixed pressure differential assumption in the single-channel model. Employing the pore doublet theoretical model, we examine how the permeability of parallel straight channels influences the dynamic response of residual nonwetting droplets. Furthermore, we compare predictive discrepancies between the single-channel and pore doublet models, integrating bypass flow, to determine critical acceleration amplitudes for releasing residual nonwetting droplets at different frequencies. Ultimately, we uncover the competitive interaction between the seismic response of residual nonwetting droplets at pore throats and bypass flow in surrounding pores. These research findings establish a robust theoretical foundation for comprehending seismic impacts on engineering, geological implications, and the potential incubation of geological disasters within the geological and environmental domains.

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Primary author: DENG, Wen (Southeast University)

Co-author: Mr YU, Shilin (Southeast University)

Presenter: DENG, Wen (Southeast University)

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