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Interface Evolution During Pore Water Evaporation in Micromodels

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The interface between liquid and vapor phases within porous media plays a pivotal role in enhanced vapor diffusion and water evaporation. The liquid-vapor interfaces can be classified into internal interfaces (pertaining to vapor diffusion) and external interfaces (associated with phase change) based on their distinct mechanisms. However, the intricate geometric and topological complexities within these interfaces pose challenges in discerning between their internal and external manifestations, hindering a comprehensive understanding of heat and mass transfer mechanisms within soil pores. In this study, a meticulously engineered Hele-Shaw cell integrated with patterned micropillars offers an innovative approach for comparing interface evolution in pores with diverse patterns. A sophisticated image-processing analysis was employed to accurately compute the evaporation rate of the pore water from the micromodels. Equivalent lengths were obtained to determine interface areas at distinct time intervals. Comparison of the continuous recession of the liquid-vapor interface in a stable micropillar pattern to the air-entry of the internal interface and pinned external interface in an unstable micropillar pattern provides an approach to quantitatively separate the internal and external interfacial evaporation rates. Furthermore, employing image processing during evaporation enables the calculation of both global and local interface curvatures. Consequently, a correlation between the characteristic curvature radius and the averaged interfacial evaporation rate was established, consistent with prior experimental findings documented in the literature. The distinction between internal and external evaporation rates offers a fresh perspective, shedding light on the mechanisms that drive enhanced evaporation and diffusion within porous media.

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