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Preferential evaporation from heterogeneous porous media

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Displacement of evaporation drying front into initially saturated porous medium is driven by capillary gradients between large pores at the front supplying the evaporation process at the surface. In heterogeneous media containing sharp textural contrasts, drying front displacement patterns follow preferential liquid flow from coarse textured regions in support of evaporation from saturated fine textured regions connected to the surface. Hele-Shaw cells with vertical and horizontal sharp textural interfaces between coarse and fine sand domains were used to study water distribution during evaporation using neutron transmission technique. For vertical textural interfaces, evaporation from saturated fine sand was sustained by liquid flow from adjacent coarse sand resulting in preferential advance of the drying front exclusively into coarse sand region. Direct evidence of water flow pathways from coarse to fine sand was obtained with neutron radiography using heavy water as a tracer. A characteristic length defining maximum drying front depth (in the coarse medium) is determined by the difference in air-entry values of the two media. In our experiments, viscous resistance exerted no effect on maximum front depth even when flow cross section (fine sand relative area) was reduced from 75% to 8% for similar external evaporative conditions (viscous limitations would be important for clayey media). Preferential evaporation patterns from texturally-heterogeneous media during capillary driven liquid flows result in an increase in overall evaporative losses relative to porous media represented by homogenous effective properties.