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Preferential evaporation in the presence of textural contrasts

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An evaporation drying front propagating into an initially saturated porous medium may exhibit irregular patterns due to variations in pore sizes where water is displaced from large pores to support evaporation from saturated smaller pores. Such processes are accentuated in heterogeneous porous media with large textural contrasts and result in preferential drying and mass flow of coarse textured regions in support of evaporation from fine textured and saturated regions. These effects were analyzed using Hele-Shaw cells filled with sandy materials forming sharp textural interfaces between coarse and fine domains. Water distribution during evaporation was delineated using the neutron transmission technique and images with dyed water. For cells with vertical textural interfaces evaporation took place from saturated fine sand region via mass flow from the coarse sand region in which the drying front propagated. Direct evidence of water flow from the coarse to the fine sand was established by using heavy water as a tracer. The distance between drying front position in the coarse sand and the stationary evaporating surface in the fine material increases to a value corresponding to the difference in air-entry values of the two materials. To examine potential limitations due to water flow in the fine material, the thickness of the fine material region was progressively decreased. For cells in which the textural interface was horizontal with fine over coarse sand, the drying front initially propagates in fine sand until air enters the coarse material resulting in abrupt and large amounts of water displaced from coarse to fine layer. The driving force for such cavitation-like rapid redistribution, is the capillary pressure difference between the air entry values of the media. Subsequently, drying front invades preferentially the coarse sand while liquid distribution in the fine sand remains constant. The analysis of the preferential evaporation from the fine material was complemented by small scale studies based on synchrotron

light and invasion percolation modeling.