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Dynamics of transition from stage-1 to stage-2 evaporation from porous media

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The early stages of evaporation from porous media are marked by a relatively high and constant evaporation rate (the so-called stage-1 evaporation) sustained by capillary liquid flow from the porous medium interior. Following interruption of hydraulic connections at a certain drying front depth, the vaporization plane migrates below the surface leading to transition to stage-2 evaporation limited by vapour diffusion through the porous medium. The nature of the transition and the wide range of transition dynamics from stage-1 to stage-2 were studied using evaporation experiments from sand-filled Hele-Shaw cells (172x81x4 mm) with three mean particle sizes of 0.27, 0.46, and 0.84 mm. The initially water saturated cells were placed on digital balances (cell top exposed to air) to record evaporation rates. Experiments were conducted in an environmental chamber where the relative humidity and temperature could be varied and controlled accurately. The effects of grains size, ambient temperature and relative humidity (both affecting potential evaporation rates) on transition dynamics were systematically evaluated. The results illustrate the role of potential evaporation rate on transition duration and shape transcending the expected scaling with cumulative mass loss that defines the evaporative characteristic length. The transition becomes more abrupt at higher atmospheric demand perhaps due to enhanced role of viscous effects that accelerate pore disconnection. Pore size did not affect the shape of transition much except for the medium sand with prolonged transition (the exact pore size distribution needs to be examined). Interestingly the evaporation rate at the onset of stage 2 was not affected by atmospheric conditions (Shokri and Or, 2011).