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The change in hydraulic conductivity and flow paths associated with the change in the degree of saturation of a rock

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In a geologic medium above a water table, water and air coexist in pores because of repetition of irregular water infiltration and drying. When water infiltrates in an unsaturated geologic medium, hydraulic conductivity is presumed to be affected by the fraction of residual pore water. A geologic medium has many pores that are different in shape and size, and the flow paths of water would change depending on the degree of saturation. It is important to elucidate the changes in hydraulic conductivity and flow paths associated with the change in the degree of saturation for accurate prediction of the water transport in unsaturated medium. In this study, we adjusted the degrees of saturation by drying a core of Fontainebleau sandstone (connected porosity: 6.1%; main pore size: 1 - 10 micro meter) which was preliminary saturated, and hydraulic conductivities were measured by constant head permeability tests for each degree of saturation. We further focused on the pore size as one of the important parameters that may control water flow, and evaluated how the amounts of water in pores of varied sizes change depending on the degree of saturation. Gas pressure was applied to the lower side of the rock core with a given degree of saturation, the amount of expelled water was measured, and the amounts of expelled water from each size of pores were determined based on Young-Laplace equation which describes the relationship between gas pressure and pore radius (Differential pressure = 2*Surface tension*cosine(Contact angle) / Pore radius). As a result, hydraulic conductivity decreased from 1.5×10^{-7} m/sec to 6.4×10^{-9} m/sec with decreasing the degree of saturation from 100% to 48%. We also found that larger pores (7 - 9 micro meter) lose water and the radius of water-containing pore gradually decreases with decreasing the degree of saturation.

Keywords: rock, hydraulic conductivity, unsaturated hydraulic conductivity, flow path, drying