

砂岩内部の水の毛管上昇速度：実験とモデリング

The rate of capillary rise in sandstone: experiment and modeling

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Knowledge of the mechanism of capillary rise is important in considering water transport near the ground surface. Capillary rise in a geologic medium is often analyzed using Lucas-Washburn (L-W) equation which describes the relationship between capillary rise height (h) and elapsed time (t) in a tube with a given pore radius. However, it is known that a radius significantly smaller than the major pore radii in the rock needs to be used for the L-W equation in order to well reproduce the measured h - t relationship. As a reason for this phenomenon, Dullien et al. (1977) considered a model in which pore radius repeatedly varies between larger value and smaller value, and showed that the apparent pore radius calculated by the model becomes smaller than the smaller radius. In addition, recently Tsunazawa et al. (2016) proposed the importance of the branching of flow path of capillary rise. Combination of the effects of the pore size variation and the pore branching may be a key to better understand the rate of capillary rise. Bearing this in mind, we investigated capillary rise in Berea sandstone. The main pore radii of the rock range between 0.7 to 10 μm with the most abundant radius at 2 μm , as measured by a “water expulsion method” (Yokoyama and Takeuchi, 2009; Nishiyama et al., 2012). h - t relationship was measured using a core of the sandstone, and by fitting the L-W equation to the experimental result, the pore radius which can best reproduce the experimental result was obtained to be 0.35-0.60 μm . On the other hand, as an attempt of the modeling of capillary rise, we evaluated how water advances at the branching point of narrower pore and wider pore during the capillary rise, based on the concept of Tsunazawa et al. (2016). The result showed that water selectively proceeds in narrower pore at almost entire position in the rock, because the capillary pressure arising in narrow pore is greater than that in wide pore. Following the analysis of the effect of branching, the flow path was assumed as a tube in which pore radius repeatedly varies between the most abundant pore radius and narrower pore radius, and the apparent pore radius was calculated using Dullien's model. The obtained value (0.43 μm) agreed well with the pore radii (0.35-0.60 μm) obtained by fitting L-W equation to the experimental result.

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