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Visualization of Colloid Retention onto Interfaces in Unsaturated Porous Media

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Little is known about the complex mechanisms of transport and retention of colloids at the pore scale in soils. Measurements of colloid and microbial transport have been limited to the evaluation of breakthrough curves from column experiments or the visualization in micromodels with limited applicability to realistic conditions. With the experimental setup we propose, colloid transport and retention can be observed directly on the scale they are occurring. Our visualization system consists of a horizontal flow chamber filled with clean quartz sand through which a constant water flow can be adjusted. Hydrophilic (carboxylated latex) and hydrophobic (polystyrene latex) colloids as well as bacteria (Escherichia coli) in aqueous solution are injected using a syringe pump. The colloids and the bacteria are fluorescent, their diameter is 1 μm. The aqueous phase is stained with rhodamine B. The chamber is mounted under a confocal laser scanning microscope which allows the acquisition of time series and 3D reconstruction of pore-scale images. Three spectral channels are used: a 488 nm (argon) line excites the colloid fluorescence, a 543 nm green (HeNe) line excites rhodamine B fluorescence, and a transmitted light channel that delineates the sand grains. This offers the possibility of achieving high contrasts for detecting the colloids and the water phase. Methods of digital image analysis are presented which determine the number and area of moving and retained colloids. The results can be used to verify simulation model parameters concerning colloid transport, such as quantitative measurements for determining collision efficiencies.