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Statistics of the Local Electric Currents in Porous Geo-Materials Obtained by Pore-Scale Computer Simulations

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Computer simulations of steady-state electric currents in fluid-saturated porous sediment/rock were performed using pore-scale X-ray microtomographic images (Refs 1, 2). An example of the simulated local current magnitude is shown in the figure below (Berea sandstone image, 0.64mm x 0.64mm x 0.64mm, Solid voxels are dark blue. The direction of the macroscopically applied field gradient is indicated by a solid arrow). The main results are as follows. (i) The histogram of the magnitude of the local current flux vector obeys a unimodal log-normal distribution having a long positive tail. Simulations using model images were also performed to show that the flux broadening in large pores and the flux mixing at the pore network junctions are responsible for the log-normal shape. (ii) The simulation enabled us to directly visualize pore voxels with large and small fluxes, confirming the existence of transport pores and stagnant pores. Because of the unimodal nature, however, it was difficult to distinguish transport pores and stagnant pores using an objective threshold in the histogram. (iii) Another histogram of the flux vector component along the direction of the macroscopic potential gradient was analyzed. A negative tail was found in the histogram, indicating that local counter currents exist in the porous geo-materials. However, the population and intensity of the counter fluxes are too small and weak to contribute to the overall charge transport across the porous media system. A long positive tail representing a large-flux current pathway was also observed in the histogram. However, again, the population of the large-flux transport pores is small. As a result, the main conveyer of the electric charge is the stagnant pores (not the transport pores), which have small positive flux values but a large population. The present study was supported in part by JSPS KAKENHI (No. 23241012).

References:
[1]Y. Nakashima and T. Nakano (2012) Transport in Porous Media (in review)
[2]Y. Nakashima and T. Nakano (2011) Journal of Applied Geophysics. http://dx.doi.org/10.1016/j.jappgeo.2011.06.021

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