QUANTIFYING MIXING AND SUBSEQUENT REACTIONS ACROSS A HETEROGENEOUS POROUS INTERFACE

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We consider a column experiment to study the 1-D transport of a conservative scalar across a 'macroscopically' sharp interface between two porous media of differing hydraulic conductivity. A recent work by Berkowitz et al. [1] demonstrates that the classical advection dispersion equation fails to accurately predict transport across such an interface, particularly at low flow velocities, and attributes this phenomenon to the presence of the interface between the two media. In an effort to develop a better understanding of this phenomenon, we are interested in (a) verifying these observations and fully resolving the evolving concentration field in space and time, (b) how the presence of the interface changes mixing dynamics and (c) inferring how the presence of an interface could affect a mixing driven chemical reaction. In particular, by studying the dynamics within the column, we want to accurately quantify the concentration field and scalar mixing rate at and close to the interface. To this end we use light reflectrometry; this requires the development and application of sophisticated image processing methods.

In general, non-intrusive optical observation techniques are invaluable laboratory tools to study the transport of a visual tracer in experiments of flow and transport through porous media. By collecting digital images and carefully creating calibration data, Lambert Beer's law can be used to relate reflected light intensity to the concentration of a colored conservative or re active tracer. T he resulting data can often be noisy, posing a serious concern for the quantification of mixing as this relies not only on a ccurate measurements of concentration, but more importantly concentration gradients, which are particularly sensitive to noise. Crude averaging and interpolation methods will excessively smooth data resulting in underestimations of mixing measures. In this study we build upon and apply image processing algorithms based on directional kernel regression methods to filter noise and extract the necessary information to quantify concentration profiles and mixing measures such as the scalar dissipation rate or dilution index.

[1]: Berkowitz, B., Cortis, A., Dror, I., and Scher, H. (2009). "Laboratory experiments on dispersive transport across interfaces: The role of flow direction." Water Resources Research, 45, W02201.