

HYPERBOLIC THEORY FOR HETEROVALENT ION-EXCHANGE

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Ion-exchange is one of the most prevalent environmental reactive transport processes that affects groundwater quality in coastal aquifers and determines the feasibility of aquifer recharge. Ion-exchange has long been recognized as a chromatographic process characterised by strong and non-linear coupling and chromatographic models have been able to match laboratory experiments and field observations. Recently high quality experimental data on heterovalent systems has prompted us to revisit the problem and extend the hyperbolic theory for the Riemann problem to heterovalent systems. Unlike the homovalent case, the heterovalent case is not of Temple class, i.e. the Hugoniot-locii and the integral curve do not coincide, and we present general treatment of heterovalent ion-exchange. We highlight the importance of the hodograph plane, i.e. the composition space, in the construction of semi-analytic solutions and the identification of the different types of displacements. We present comparisons between theory and available experimental data as well as high resolution numerical simulations. Hyperbolic theory shows that experimental data is currently not available for all displacement types and how the theory can guide experiments to provide missing data. Finally, we consider the ability of Riemann solvers for multi-component ion-exchange to reduce numerical dispersion in numerical simulations.