Modelling saline water intrusion processes in dual porosity media using centrifuge permeameter techniques

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We present an interrupted flow technique using a centrifuge permeameter to characterise the intrusion of saline water in dual porosity media. Duplicate semi-consolidated and saturated clay samples (40 mm length × 100 mm diameter) were cored with minimal disturbance from 25.0 m depth at a field research site in New South Wales, Australia, where the clay acts as a natural low permeability barrier between saline groundwater (EC = 12,876 μS/cm) at 20 m depth and relatively fresh groundwater (EC = 2,640 μS/cm) at 40 m depth. Duplicate clay core samples were first saturated using native groundwater (EC = 6,870 μS/cm), and then permeated using D_2O tracer labelled saline groundwater (EC = 12,876 μS/cm) at constant centrifugal force and steady-state flow. Analysis of solute breakthrough curves, derived from δD and major ion (Na, Ca, Mg, Cl) concentrations within effluent samples, indicates dual porosity behaviour for all samples tested, with a long "concentration vs. time tail" recorded. Prior to full solute breakthrough the samples were removed from the centrifuge and allowed to stand (at 1 *g*) for fixed time period with their influent removed. The influent was then replaced and the samples were centrifuged again. A negative spike in the δD and solute breakthrough curves was then recorded indicating solute exchange (via molecular diffusion) between the preferential flow network and the low K domain during the aforementioned flow interuption period. Analysis of visual dye tracer and δD concentrations in dissected sections of the core recorded preferential flow paths to correlate with: (i) fractures networks; and (ii) paleo root-hole features.

Results provide clear evidence that heterogeneities in clay-bearing media lead to significant permeability enhancement and associated solute transport rates. Dual porosity models were developed to simulate the observed behaviour and test hypotheses regarding the exchange of solutes between transport domains.