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Semianalytical Solutions of Radioactive Solute and Colloid Transport in Layered Fractured Media

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In this paper, semianalytical solutions are developed for the problem of transport of radioactive solutes or colloids through a layered system of heterogeneous fractured media with misaligned fractures. The tracer transport equations in the matrix account for (a) diffusion (molecular or colloidal), (b) surface diffusion (for solutes only), (c) mass transfer between the mobile and immobile water fractions, (d) linear kinetic or equilibrium physical, chemical or combined sorption (for solutes) or filtration (for colloids), and (e) radioactive decay or first order chemical reactions. Any number of daughter products of radioactive decay (or of a linear, first-order reaction chain) can be tracked. The tracer transport equations in the fractures account for the same processes, in addition to advection and hydrodynamic dispersion. Additionally, the colloid transport equations account for pore size exclusion (straining) and velocity adjustments related to the colloidal size. The solutions, which are analytical in the Laplace space, are numerically inverted to provide the solution in time, and can accommodate any number of fractured and/or porous layers.

The solutions are verified using analytical solutions of limiting cases of solute and colloid transport through fractured and porous media. The effect of important parameters on the transport of H-3, Np-237 and Pu-239 (and its daughters) is investigated in several test problems. Test problems of transport of Pu-239 colloids in multi-layered systems indicate significant colloid accumulations at straining interfaces but much faster transport of the colloid than the corresponding strongly-sorbing solute species.