Scale Dependence of Colloid-Associated Radionuclide Transport

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Two experiments were conducted in which water from a nuclear test cavity in Nevada containing high concentrations of natural colloids and ^{3}HHO was tranported through columns packed with a crushed volcanic tuff. In one experiment, the cavity water was spiked with ^{137}Cs, and in the other it was spiked with ^{239}Pu(IV) nanocolloids. The radionuclides strongly partitioned to the natural colloids present in the water. A separate column was used for each experiment. After the breakthrough curves of the radionuclides and colloids were obtained, the unanalyzed portion of the samples having relatively high concentrations were combined and re-injected into the respective columns as a second pulse. This procedure was repeated again for a third injection.

We observed measurable filtration of the colloids after the first injection into each column, but the subsequent injections exhibited no apparent filtration, suggesting that the colloids that remained mobile after relatively short transport distances were more resistant to filtration than the initial population of colloids. Likewise, we observed significant desorption of ^{137}Cs from the colloids after the first injection, but subsequent injections exhibited much less ^{137}Cs desorption (much greater ^{137}Cs colloid-associated transport), suggesting that the ^{137}Cs that did not desorb during the first injection represented a fraction that was more strongly adsorbed to the mobile colloids than the initial ^{137}Cs inventory. The ^{239}Pu recoveries decreased in the second injection compared to the first, then increased in the third injection. We will discuss potential explanations for this observation, but the greater recovery in the third injection compared to the second suggests that the mobile fraction of colloid-associated Pu tended to transport more efficiently with time and distance, similar to the Cs. These results suggest a transport scale dependence in which the fraction of colloids and colloid-associated radionuclides remaining mobile at downstream points along a flow path have a greater tendency to continue to remain mobile along the flow path than colloids and radionuclides observed at upstream points. This 'natural selection' process for highly mobile colloids and colloid-associated radionuclides has significant implications for predictive models of colloid-associated radionuclide transport over large distances.