Sandia National Laboratories

Sandia Colloid Geochemistry and Transport Laboratory

Need

Colloid-facilitated contaminant transport has been recognized as a potentially important mechanism for movement of harmful materials to the biosphere. The impact of colloidal particles on contaminant transport should be considered, particularly in shallow subsurface environments. Depending on the geochemistry of the system and the nature of the porous medium, the presence of naturally occurring or introduced colloidal particles may be of trivial importance or may even be beneficial. However, in cases where colloidal transport may be significant, engineered modification of the contaminant source can be conducted to attenuate movement.

Kinetic Stability Experiment.

Description

The Sandia Colloid Geochemistry and Transport (SCGT) Laboratory has successfully demonstrated that colloidal particles do not have a significant impact on radionuclide transport at the Waste Isolation Pilot Plant (WIPP), a proposed transuranic waste repository located near Carlsbad, New Mexico. The approach focused on laboratory screening studies, rather than an expensive field sampling and characterization program. The WIPP colloid investigation focused on bounding the impact of colloidal particles by investigating:

- Colloid stability in the near- and far-field aqueous transport paths
- Limitations in the concentrations of contaminants associated with colloidal particles
- Interactions between colloidal particles and the porous medium during transport

The systems-level approach developed for the WIPP Colloid Research Program is suitable for many sites.

Example Projects

Solubility of Humic Substances

Humic substances, colloidal particles known for their strong affinities for metals, are expected to be present in the proposed WIPP repository where they will interact with dissolved actinides. Because humics may form *in situ* from condensation reactions involving microbial metabolites, it has not been possible to determine conclusively the total concentration that may be present at the WIPP. Consequently, the SCGT laboratory utilized a bounding approach in which humic solubilities, humic-binding site capacities, and humic-actinide complexation constants were measured. Experiments were conducted to quantify the free concentration of a range of types of dissolved humics as a function of ionic strength, but particularlythe concentrations of the divalent cations Ca^{2+} and Mg^{2+} in WIPP groundwaters. This approach provided a means to realistically bound the humic-actinide contribution to the WIPP source term.

Physical Filtration of Microbes

Salt-tolerant microbes are expected to be present in the proposed WIPP repository where they will subsist on cellulosic substrates and nutrients accompanying the waste. In addition to quantifying the contribution of bioaccumulated actinides to the WIPP source term, an important aspect of evaluating the performance of the WIPP is to assess transport of microbial actinides in the far-field. Transport experiments were conducted with crushed-rock and large intact-core samples to evaluate microbe transport under WIPP conditions. By varying the test configurations and geochemistry, it was possible to demonstrate that WIPP-relevant microbes are attenuated by WIPP far-field rock primarily by physical filtration. Through those experiments, a means to calculate microbe-facilitated actinide transport rates was developed for use in performance assessment calculations.

Behavior of Mineral-Fragment Colloids

Dispersions of colloidal particles comprised of submicron-size mineral fragments are readily destabilized by increasing the ionic strength. Because the rate of coagulation of mineral-fragment type colloidal particles decreases as coagulation progresses, some particles remain suspended for fairly long periods. To assess the impact of that residual concentration on actinide mobilization at the WIPP, measurements were made at the SCGT laboratory on a range of mineral fragment colloids. Associated actinide concentrations were estimated using particle surface areas. Using that bounding approach, costly experiments involving actinides were avoided, and mineral-fragment type colloids were shown to have negligible impact on WIPP performance.

Experimental Capabilities

Sandia Colloid Geochemistry and Transport Laboratory:

- Electrophoretic mobility analyzer (Doppler shift)
- Submicron particle size analyzer (photon correlation spectroscopy)
- Coulter-principle particle counter
- High-resolution submicron particle flow-through spectrometer
- Large- and small-scale tangential filtration
- BET surface area analyzer
- Light-scattering photometer
- Packed-column transport apparatus; Autotitration systems

Associated Sandia laboratories devoted to subsurface transport of radionuclides:

- Large-scale triaxial flow-through system for radioactive materials
- Computer-aided emission and transmission tomographic imaging
- Mass spectrometry; Automated NaI gamma spectroscopy
- Inert atmosphere gloveboxes
- Automated low-level alpha/beta liquid scintillation counting equipment
- Scanning and transmission electron microscopy; Energy-dispersive X-ray spectroscopy
- Powder X-ray diffraction; X-ray fluorescence spectrometry
- Polarography
- Inductively- and direct-coupled plasma emission spectrometry
- Graphite-furnace atomic absorption spectrophotometry
- Ion chromatography

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