Pu at the INL: Questions Concerning Colloid Facilitated Transport

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The condition

- **Inventory of Pu at the Subsurface Disposal Area[1]**
  - **1,850 Ci ^{238}Pu**
  - **63,000 Ci ^{239}Pu**
  - **14,100 Ci ^{240}Pu**
- **113 kg Pu estimated in disposed HEPA filters used in high temperature processing, mostly from Rocky Flats. 4.6 kg Pu may be in a size range ($\leq 1\mu m$) that can be transported as colloids in the subsurface[2].**
- **Subsurface transport of Pu (dissolved or colloidal) is not considered to be a risk factor. Detection of Pu in perched water and the aquifer has been rare and often uncertain. However, public perception is still important.**
- **INL's obligation: to assure the public that contaminants will not be a threat to human health.**
- **Long-term monitoring must be designed with an ability to correctly interpret observations and accurately predict future transport.**

1 DOE/ID-11241

2 *Batcheller, T. A. and G. D. Redden (2004). Colloidal Plutonium at the OU 7-13/14 Subsurface Disposal Area: Estimate of Inventory and Transport Properties, Idaho National Laboratory, ICP/EXT-04-00253*

Challenges

- **Source forms are not completely known (although mass balance is reliable)**
- **Need to accurately predict Pu transport in the context of long term monitoring. The K_d approach may not be adequate, or at least requires justification.**
- **Detection of Pu that is transported as colloids is difficult due to sample availability, limitations of the analytical methods and the possibility of creating sampling artifacts.**

Highest Impact Needs

1. Improved field sampling methods for colloids and Pu associated with colloids
2. Better conceptual models for colloid transport using colloid tracer tests
3. Representative colloid transport and filtration models for INL site conditions (vadose zone, fractured basalt, sedimentary interbeds, episodic infiltration)
4. Also, better characterization of the source terms (soluble and particulate forms, and transformations)

Cross-cutting topics

- Site characterization – microscopic and macroscopic (e.g., porosity distributions)
- Flow in fractures
- Episodic flow
- Variations in water chemistry and composition
- Flow paths and flow evolution in Vadose zone vs. saturated systems
- Bacterial transport

Other Issues

- Heat
  - Impact on Pu form
  - Impact on other wastes
  - Impact on moisture
- Bioturbation

1. Improved field sampling methods for Pu and colloids

- **Distinguish between colloids and dissolved species**
- **Prevent artifacts: Are sampled colloids really mobile prior to sampling?**
- **Collect and preserve samples for analysis of signatures (decay products and isotopes)**
- **Consider sample volume constraints – limits, impact on colloid capture**
- **Select analytical methods with detection limits for soluble and colloidal Pu species that are appropriate for monitoring and evaluating model predictions**

2. Colloid Tracer Tests

- **Analogs for Pu colloids needed (e.g., properties similar to PuO_2)**
- **Flow paths, flow velocity**
- **Fractures vs. interbeds**
- **Colloid competition**
- **Chemistry perturbations that impact colloid mobility**

- **<u>Support with laboratory and intermediate-scale experiments</u>**

3. Accurate colloid transport and filtration models

- **Accounting for INL subsurface characteristics**
  - **Episodic infiltration**
  - **Vadose zone**
  - **Fractured basalt and sedimentary interbeds**
- **K_d for colloids does not have a defensible scientific basis**
- **Reversibility (colloid attachment vs. detachment)**
- **Colloid transport at the air-water interface in porous media**
- **Physically and chemically heterogeneous media**
- **Modes of filtration**
- **Interpretation of field data**

- **Potentially useful recent advancements**
  - **Modeling: smoothed particle hydrodynamics, Lattice Boltzmann, computational power**
  - **Visualization methods: flow paths, fluid distributions, colloid position**

4. Source Term Characterization

- **Corrosion products**
- **Formation of colloidal particulates**
- **Chemistry and biochemistry of Pu solid and solution species**
- **Stability of Pu colloids**
- **Impact of organics on:**
  - **Pu speciation and transformations**
  - **Colloid mobility**
  - **Microbial activity**
- **Decay products**
  - **As future contaminants**
  - **As source signatures**
- **Recoil – impact on element and particle mobility**