Investigation of dominant hydrogeochemical processes influencing uranium transport in groundwater at a retired explosives test site

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Abstract

The hydrogeological conceptual model and the reactive transport model are preliminary. From the initial geochemical and reactive transport model outputs, the following suggestions can be made about the site.

- The chemistry of the aquifer is governed by characteristic silicate weathering reactions.
- The Aquifer is highly oxidized, implying uranium will likely exist in the more mobile oxidized state.
- The Majority of uranyl ion will complex with carbonate ions.
- Uranium-bearing secondary phases are dominantly undersaturated, except for Swartzite in water in W-812-01 and W-812-02.
- Uranium carbonates will affect the amount of sorption/interaction with a surface.
- Sorption may be dominant process, but refinement of model is needed.

Future Work

Further research includes the following activities and objectives:

- Further evaluation of site-specific data.
- Refinement of advective-dispersive transport model.
- Further evaluation and elimination of attenuation processes.
- Input of different processes into the reactive transport model to determine their relative importance.
- Inverse-modeling to determine additional potential processes.
- Determine actual reactive mineral content in Tnbs/Tnbs rocks (whole rock mineralogy analysis).
- Calibrate model to site data and conduct sensitivity analyses.
- Determine if dual porosity models hydraulics effectively

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Objectives and Methods

Determining the dominant processes influencing uranium transport will be completed by the following objectives.

A. Evaluate 14 years of hydrogeologic/chemical data

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Water Chemistry Values</th>
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<tbody>
<tr>
<td>W-812-01</td>
<td>Ca = 9.5 mg/L, Mg = 13.1 mg/L, pH = 6.9, U = 0.17 mg/L</td>
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<tr>
<td>W-812-02</td>
<td>Ca = 9.5 mg/L, Mg = 13.1 mg/L, pH = 6.9, U = 0.17 mg/L</td>
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<td>W-812-03</td>
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<tr>
<td>W-812-05</td>
<td>Ca = 9.5 mg/L, Mg = 13.1 mg/L, pH = 6.9, U = 0.17 mg/L</td>
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</tbody>
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B. Create an hydrogeologic conceptual model of the Tnbs/Tnbs, sandstone aquifer

C. Apply a geochemical and reactive transport model, Geochemist’s Workbench V.10, to identify specific processes, aquifer properties, and site conditions controlling uranium transport.

Results

Aqueous Speciation

- Bicarbonate (HCO\textsubscript{3}) complexes bond strongly with uranyl ions (UO\textsubscript{2}\textsuperscript{+}) in groundwater. Uranium speciation in solution is dominated by uranyl carbonate complexes.

Mineral Saturation Indices

Preliminary Reactive Transport

- Preliminary simulations of 1-D advective reactive transport along a transect from W-812-01 to W-812-09 were conducted with the following parameters:
  - UO\textsubscript{2}\textsuperscript{+} sorption to HFO modeled after Dzombak and Morel (1990)
  - Diffuse double-layer surface complexation theory
  - Sorption of uranyl carbonates to HFO % Volume of 0.01
  - Retardation factors and distribution coefficients (K\textsubscript{d}) calculated from breakthrough curves of UO\textsubscript{2}\textsuperscript{+} and a conservative tracer.
  - Various HCO\textsubscript{3} concentrations were used to show effect on sorption

\textsuperscript{1} Relationships between K\textsubscript{d} (and UO\textsubscript{2}\textsuperscript{+}) sorption decrease with increasing HCO\textsubscript{3} concentration.

Research Questions

1. What are the dominant processes causing the observed attenuation of the depleted uranium?
2. Can a reactive transport model be used to simulate uranium transport in the aquifer?
3. If so, do the simulations indicate system has the ability to attenuate the uranium indefinitely?

Site Description

5 monitoring wells are screened 50-70 feet below ground surface within the Tnbs/Tnbs, sandstone aquifer.

Oblique view of Building 812 site

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