Synthesis, Technology Transfer, Future Research Priorities

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USGS
Objectives of Toxics Program Research on Contamination in Fractured Rocks

• Advance understanding of physical, chemical, and microbiological **processes and properties** affecting contaminant fate and transport in fractured rocks.

• Investigate processes of **contaminant remediation** and methods for **monitoring** remediation.

• Develop a **hierarchy of quantitative tools** to help synthesize results and improve understanding of processes.

• **Transfer** findings, insight, and methods.
Wide Variety of Field & Lab Methods Used to Achieve Research Objectives

Geology

Geochemistry

Contaminant Delineation

Water-Rock Interaction

Aquifer & Tracer Testing

Geophysics

Microbiology

Carbon Isotope Analysis

Bioaugmentation
Quantitative Tools: A Key Component of Research on Fractured Rock Contamination

Contaminant Fate and Transport

A Range of Quantitative Tools

Biogeochemistry

Remediation

USGS

science for a changing world
Simple Quantitative Tool: Screening Method for Assessing Effect of GW Flux on Thermal Conductive Heating


Effect of hydraulic gradient on temperature between the two heating wells
Fairly Simple Tool: Model for Designing Injection of Bioaugmentation Amendments

2D flow model with very simple heterogeneity representation

Particle tracking simulation: Inject amendments then flush well

Migration of amendments toward pumping well
More Complex Quantitative Tools

Site-scale 3-D GW flow model calibrated to aquifer test data and heads

2-D solute transport model simulates forced-gradient tracer test

2-D reactive transport model simulates biodegradation

Process Understanding
Uncertainty Analyses
Technology Transfer

• Transfer of new **methods**

• Guidance on **which characterization activities are most important** to conduct, for:
  • Making informed decisions about remediation strategies
  • Monitoring remediation

• **Generalization of results and insight** from NAWC, to guide activities and help understand processes at other sites.
Technology Transfer: In Situ Diffusion Test at NAWC

- Has promise as a cheaper alternative method to coring for estimating contaminant concentrations in rock matrix.
Technology Transfer: Bioaugmentation Experiment at NAWC

**Analytes:**
- Field parameters ($O_2$, pH, SC, turbidity)
- Dissolved anions, cations, nutrients
- Metals
- VOCs
- Dissolved gases
- Volatile fatty acids
- Microbial DNA
- Dissolved hydrogen
- Isotopes of VOCs
- Isotopes of DOC, DIC

- Identify subset of analytes most useful for understanding effects of bioaugmentation, to help streamline monitoring at other sites.

- Insight gained about designing and monitoring bioaugmentation: Applicable to other sites.
Looking To The Future: Examples of Research Priorities

Contaminant Fate and Transport
Fracture surface area in contact with transported contaminants

Biogeochemistry
Role of microbes in rock matrix

Remediation
Effective monitoring methods

To be continued on Wednesday
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