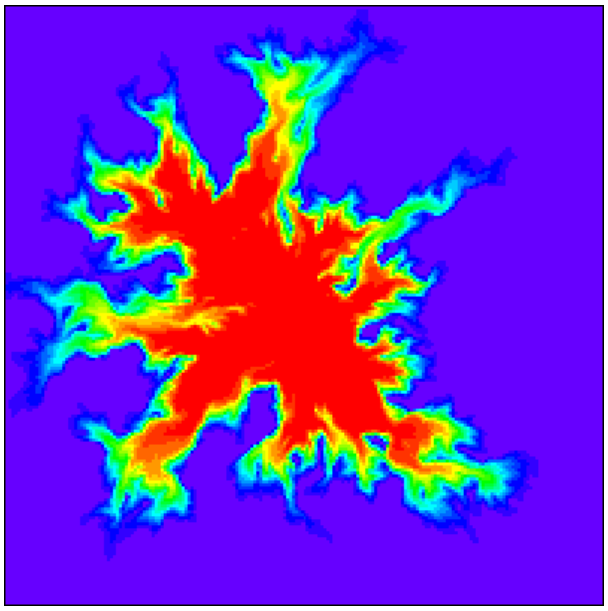
Sandia National Laboratories

Field-Scale Tracer Testing: Determination of Controlling Transport Processes in Fractured and Heterogeneous Subsurface Environments

Need

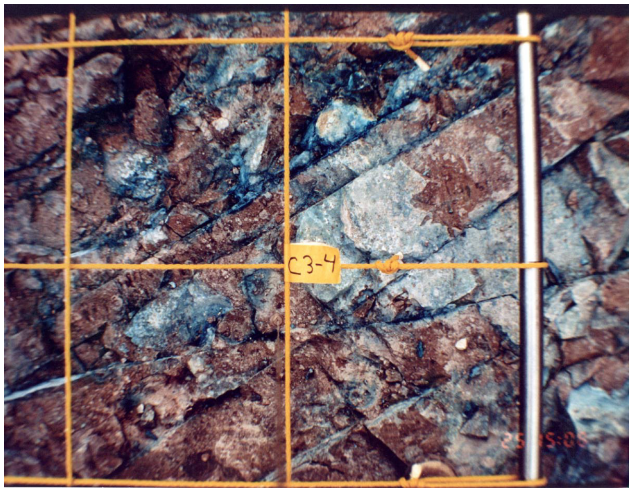
Understanding the processes controlling subsurface transport is a key element in the demonstration of safe disposal of radioactive and / or hazardous wastes, as well as the design and implementation of effective contaminant remediation. Subsurface transport is complex, controlled by the interplay among heterogeneous geologic environments, ground-water flow, and physical / chemical interactions of dissolved and / or immiscible phase contaminants. Limited access to directly observe and sample the subsurface further compounds this complexity. Transport processes control contaminant migration, as well as contaminant retardation and isolation. Field-scale tracer testing is a highly effective technology for determining controlling transport processes, as well as important transport parameter values for use in predictive models for regulatory compliance demonstration and remediation design.



Simulation of tracer distribution after injection into a heterogeneous medium.

Description

Sandia National Laboratories has conducted research and development on field tracer test technologies, as well as project-specific applications to address a range of different technical issues. These issues include differentiation of controlling transport mechanisms at the Waste Isolation Pilot Plant [WIPP], delineation of fast path transport mechanisms in the unsaturated zone at the proposed Yucca Mountain repository, and identification of controlling transport mechanisms at uranium contaminated soils sites. Sandia's tracer testing technology includes a broad range of geologic and hydrologic settings, experimental designs, test interpretations, and incorporation of results in predictive models and risk assessments. Specific examples include:



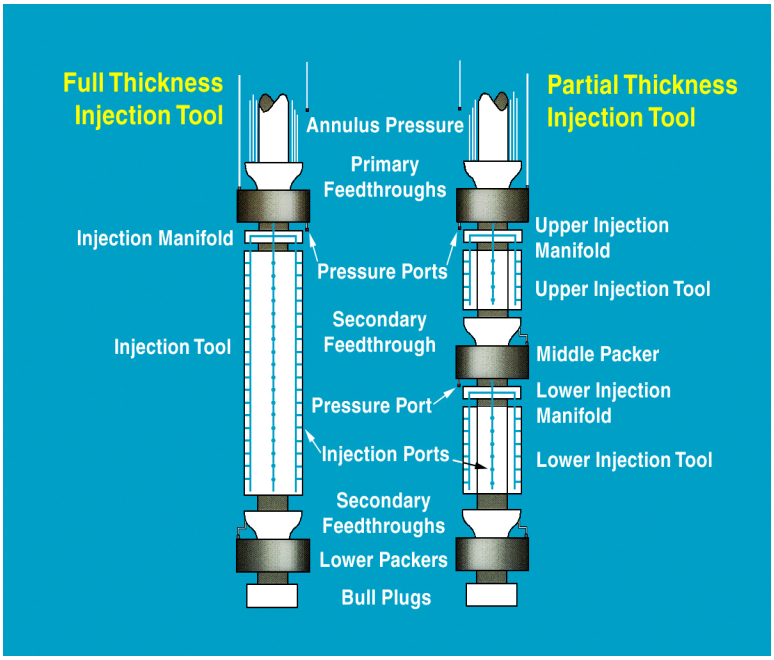
Dye tracer experiment in fractured volcanic rock.

Different Geologic and Hydrologic Settings

- Fractured dolomite
- Fractured volcanic tuff
- Fractured clay till
- Heterogeneous alluvial deposits
- Both staturated and unsaturated (vadose zone) conditions

Variety of Tracer Test Designs

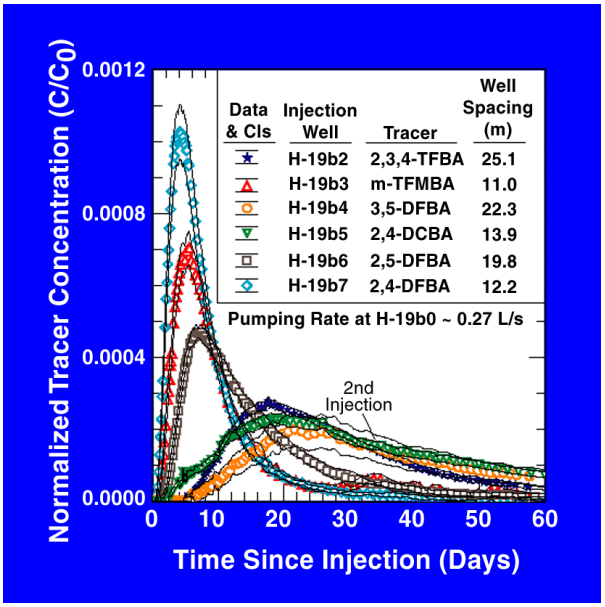
- Single-well, injection-withdrawal tests to differentiate among alternative transport models
- Multi-well, convergent flow tests to determine controlling transport parameters in fractured rock
- Multi-level tracer injection and recovery to assess vertical variability in transport characteristics
- Dye-tracer infiltration in unsaturated, fracture rock to identify and test alternative fracture transport models under unsaturated conditions
- Dye-tracer infiltration in unsaturated, heterogeneous porous media to assess potential for fast transport pathways
- Shallow, natural gradient tracer tests to determine 3-dimensional configuration of capture zones adjacent to streams and drainage channels



Downhole tracer injection tools.

Full Suite of Tracer Analysis Techniques

- Numerical simulation of tracer experiments using alternative conceptual models utilizing a variety of codes including: SWIFTII, THEMM, SUTRA, TOUGH2
- Simulation of pore-scale transport processes in discrete fractures and highly heterogeneous porous media based on modified percolation theory (PERC code)
- Analysis of the effects of multi-rate diffusion and/or sorption processes in fractured rock (STAMMT code)
- Upscaling analysis for application of hydropad-scale tracer tests to site-scale transport models for probabilistic performance assessment calculations



Tracer breakthrough curves and 95% confidence intervals (CI) for seven-well multi-well test

Advantages

Sandia tracer testing expertise extends across the full spectrum from research and technology development to application in project environments. Research and development level work assures that Sandia testing and analysis are at the cutting edge of testing and analysis technology and the maximum amount of information is extracted from any given testing effort. Tracer testing in applied, project environments provides the effective feed of key transport process and parameter information into risk and decision assessments for key system level performance assessment, as well as key technical and regulatory decisions. Extensive work with a number of projects involving rigorous Quality Assurance [QA] has resulted in the development of efficient techniques for conducting tracer tests, analyzing the results, feeding key parameters to performance assessment activities, and thorough documentation.

Selected References

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