INTEGRATED GEOPHYSICAL AND HYDROLOGICAL CHARACTERIZATION OF TRANSPORT THROUGH FRACTURED MEDIA

TECHNOLOGY NEED

In the past, wastes were routinely disposed into the vadose zone at nearly all DOE sites. Today, however, regulations require monitoring for contaminants in surrounding groundwater wells. Once toxic materials are detected in the groundwater, it is frequently too late to prevent further groundwater contamination. At the Idaho National Engineering and Environmental Laboratory (INEEL), the objective is to develop and field test a suite of instruments for characterizing and monitoring water and contaminant movement in the vadose zone prior to groundwater contamination.

The INEEL Site Technology Coordination Group (STCG) Need Numbers addressed by this project include:

- 6.1.13 *In Situ* Bioremediation of Trichloroethylene (TCE) Contaminated Groundwater in Fractured Rock at 200- to 400-Foot Depths
- 6.1.16 *In Situ* Treatment of TCE Contaminated Groundwater in Fractured Rock at 200- to 600-Foot Depths
- 6.1.22 *In Situ* Immobilization of Radionuclides (Cesium, Strontium, Uranium, and Technetium) Contaminants in Groundwater in Fractured Bedrock at 100- to 600-Foot Depths
- 6.1.23 Improved Methods to Pump Perched Water (in Fractured Basalt) from beneath the Idaho Chemical Processing Plant (ICPP)
- 6.1.28 Develop a Means for Making Organic Contaminants in the (Fractured) Vadose Zone More Available to Increase the Efficiency of Vapor Vacuum Extraction Operations. (Currently limitations exist due to diffusion rate constraints.)

This work addresses Oak Ridge STCG Need Numbers:

- HY-01 DNAPL Source Characterization and Delineation: Delineation is difficult for less permeable lenses or in bedrock fractures, but necessary to provide cost-effective remediation technologies to reduce or eliminate these persistent sources of contaminant release to groundwater.
- HY-06 Fractured Media Flow Characterization: Contaminant migration at some of the Oak Ridge facilities is controlled by fractures, joints, and bedding planes. Technology advancement is necessary to better characterize and predict how contaminants will be transported through fractured formations on a local as well as large scale in order to assess potential remediation and design exit-pathway monitoring systems.
- HY-07 Deep DNAPL Source Containment: To contain these source areas from migration or continuing long-term dissolution to the groundwater will require overcoming severe depth or resistant subsurface constraints. At Oak Ridge sites, DNAPL may have penetrated several hundred feet into fractured media, making containment extremely difficult.

The conventional or baseline technology uses tensiometers and water content sensors developed for use in soil physics investigations. The baseline technology is limited to shallow depths and to short term investigations. Prior to developing models of water movement in thick, fractured vadose zones, accurate data are required from which new hypotheses can be inferred.

TECHNOLOGY DESCRIPTION

A suite of instruments was developed here for use in thick, fractured vadose zones under earlier research projects. Developed and tested in part under this TTP were:

- Advanced Tensiometer
- Portable Tensiometer (Patent No. 5,520,248)
- The Deep Tensiometer
- Sidewall Tensiometer
- Vadose Zone Monitoring Well
- Field Matrix Potential Sensor

Under a previous TTP, the Tension Borehole Infiltrometer (Patent No. 5,644,248) was developed for determining the hydraulic conductivity over a range of soil water potentials.

BENEFITS

Improved vadose zone monitoring instruments and methods will produce field data to support the design of engineering and management controls to reduce or prevent groundwater contamination. The data that are obtained from the vadose zone monitoring instruments are directly comparable to numerical modeling outputs and will lead to more accurate modeling of future contaminant transport from a site.

CAPABILITIES/LIMITATIONS

The basic premise of this effort is to determine appropriate remediation activities based on an understanding of the complex, fractured rock system rather than blindly applying techniques developed for more homogeneous, unfractured porous media. Because strongly heterogeneous fractured systems themselves are complicated, flow and transport through them are more complicated, and therefore effective remediation is likely to be complicated as well. If remediators restrict themselves to applying simple solutions to complicated problems, they may be disappointed in the results.

COLLABORATION/TECHNOLOGY TRANSFER

Active partners in this work have included Lawrence Berkeley National Laboratory (LBNL) for developing field monitoring tools and methods for monitoring and controlling water flow and transport in fractured rocks, Stanford University for geomechanical modeling of basalt flows and field fracture mapping, and ESEA, Inc. for scientific visualization coupled to a graphical database. Government funding for closely related projects was provided by DoD and by other programs within DOE. Six of the vadose zone technologies have been licensed to In Situ Inc, Laramie, Wyoming. Two patents have been granted and six more patents are pending for vadose zone instrumentation. The INEEL has been approached by the Savannah River Site to design a full-scale monitoring system for use at the E Area disposal site. This design is being developed for possible use with cone penetrometers to further reduce installation costs.

ACCOMPLISHMENTS

A suite of vadose zone monitoring instruments was developed, intellectually protected, and licensed for commercial development. A full-scale vadose zone monitoring system is being designed and is scheduled for deployment in FY 1999.

TECHNICAL TASK PLAN (TTP) INFORMATION

TTP No./Title: ID75C221 - Integrated Geophysical and Hydrological Characterization of Transport through Fractured Media

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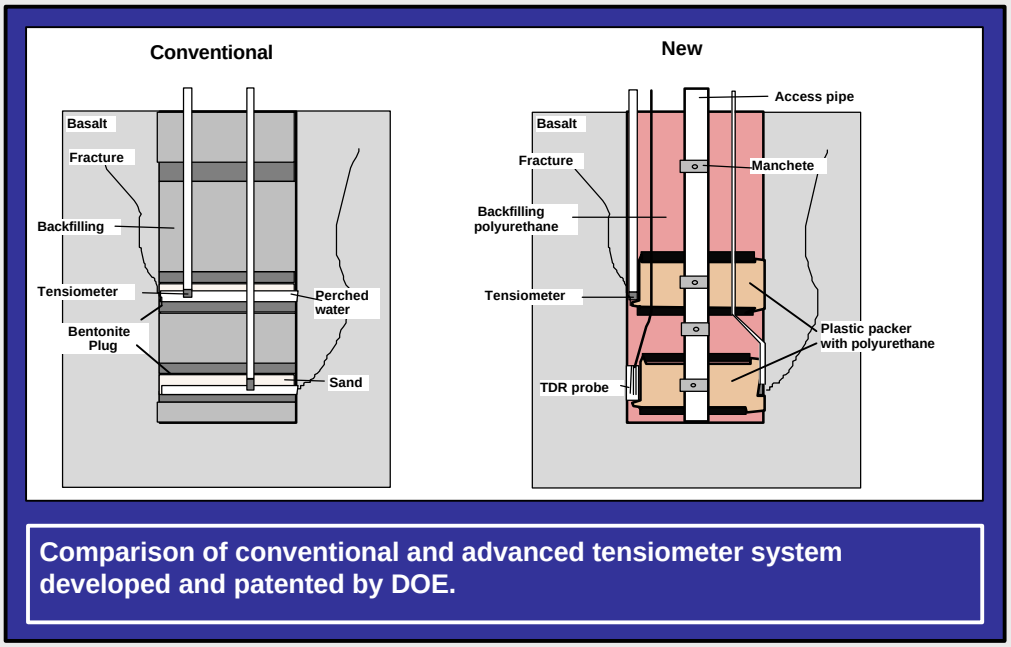

Comparison of conventional and advanced tensiometer system developed and patented by DOE.