USGS NSF GRIP Opportunity

USGS Center:	National Research Program, EB, Reston, VA
Project Title:	The Use of Heat as a Tracer in Characterizing Contaminant Transport in Fractured Rock Aquifers
Project Hypothesis or Objectives:	Chlorinated solvents have been widely used at industrial, commercial, and federal facilities for more than six decades, which has resulted in thousands of releases into the environment. In many of these situations, chlorinated solvents migrate to the groundwater table, resulting in degraded groundwater quality and the need for remediation. It is projected that the cost of characterization and the introduction of remediation at these sites will exceed 100 billion dollars in the coming decade [NRC, 2013]. Understanding processes that affect the transport of chlorinated solvents in subsurface environments is needed to design and apply remediation technologies effectively. In many groundwater systems, the effectiveness of common groundwater remediation technologies is hindered by aqueous phase chlorinated solvents that have diffused from permeable groundwater pathways into low permeability geologic materials [Sale et al., 2008]. The aqueous phase contaminants in low-permeability regions of the aquifer act as a spatially pervasive source of contamination that slowly diffuses back into the permeable groundwater pathways, which can adversely affect downgradient groundwater quality for decades, centuries, or millennia. Methods of characterizing the magnitude of the diffusive flux between permeable groundwater pathways and low-permeability regions of the aquifer are needed to assess the selection and effectiveness of remediation technologies. Laboratory analyses of low-permeability aquifer materials are commonly used to assess field-scale diffuse mass fluxes; however, it is widely recognized that the heterogeneity of the void space in aquifer materials may not be captured in laboratory-scale testing. In situ testing over relevant scales is critical in confirming the magnitude of processes affecting the fate and transport of contaminants in subsurface environments. In many instances, in situ tests are designed using benign chemical

tracers to evaluate chemical migration in the subsurface. Such tests provide a direct measure of the chemical transport, but are complicated by the design of tracer injection and recovery equipment, especially in geologic settings that are characterized by low porosity, such as fractured rock aquifers. The use of chemical tracers is sometimes hindered by high analytical costs. The use of heat as a tracer in hydrologic investigations has been discussed by Anderson [2005]. Thermal tests eliminate the need to physically retrieve a sample for analysis, as in situ equipment for monitoring thermal changes are readily available and inexpensive.

The purpose of this research is to develop methods that make use of in situ thermal responses to estimate the magnitude of chemical diffusive fluxes from low-permeability aquifer materials. This investigation will use the extensive information collected at a site of trichloroethylene (TCE) contamination in a mudstone aquifer. The information includes the detailed characterization of the TCE distribution within the rock matrix in seven closely spaced boreholes, and the detailed spatial distribution of physical and chemical properties of the rock, including porosity and organic carbon content. This investigation will include both modeling investigations and in situ experiments.

Anderson, M. P. 2005. Heat as a ground water tracer. Ground Water 43(6): 951-968.

National Research Council. 2013. Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites. National Academy Press, Washington, DC. 320p.

Sale, T., Newell, C., Stroo, H., Hinchee, R. and Johnson, P. 2008. Frequently asked questions regarding management of chlorinated solvents in soils and groundwater. Department of Defense, Environmental Security Technology Certification Program (ESTCP). Retrieved September 20, 2015, from https://www.serdp-estcp.org/Tools-and-Training/Environmental-Restoration/Groundwater-Plume-Treatment.

Duration:	3 months - 12 months
Internship Location:	Reston, VA
Area of Discipline:	Hydrogeology, Subsurface Contaminant Transport
Expected Outcome:	The intern will participate in a highly innovative research project that will introduce the participant to quantitative hydrogeologic investigations, including the collection of data and the interpretation from field testing in a complex geologic setting. The intern will work

	with world-recognized experts on fractured rock hydrology from the US Geological Survey (USGS) and will be responsible for critical components of the research program, which will culminate in the publication of products describing the results of the research. This research project continues the program of research the USGS has been conducting in characterizing groundwater flow and transport processes in complex geologic settings. This research is fundamental in addressing the missions of the USGS in areas of improving human and ecosystem health and water availability.
Special skills/training Required:	Familiarity with quantitative groundwater flow and chemical transport processes is expected. It is not anticipated that the intern will have extensive experience in groundwater flow modeling; however, fearlessness in applying groundwater flow and transport models is expected. Interns that participate in field activities will assist in the installation of equipment, which will be moderately strenuous. In addition, the intern will be responsible for documenting results and participating in the preparation of research reports and articles.
Duties/Responsibilities:	The duties of the intern will depend on the duration of the internship. Durations of 3 months will focus on modeling investigations in support of the research program. Longer tenures will include participation in the design, implementation, and interpretation of field scale experiments. The internship will be organized to facilitate the preparation of a research publication at the conclusion of the tenure.
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