Impact of Clay-DNAPL Interactions on Transport and Storage of Chlorinated Solvents in Low-Permeability Zones

Introduction

Chlorinated dense nonaqueous-phase liquids (DNAPLs) stored in low-permeability regions in the subsurface serve as long-term sources for dissolved-phase plumes. Because this storage limits the ability of remediation strategies to reach the targeted goals, it is necessary to develop better predictive models that actually reflect the processes taking place in creating this storage. Current state-of-the-science models consider the movement into low-permeability zones to occur through transverse diffusion.

However, circumstantial evidence exists that suggests more DNAPL is stored in these zones than can be accounted for by diffusion. This implies that these models, which are actively used to manage sites and design remediation strategies, may not capture the relevant phenomena. Research is needed to identify the processes that are contributing to this enhanced storage and to develop improved numerical models that can more accurately predict the longevity of the dissolved-phase plume.

Low-permeability zones in the subsurface contain clay. Previous research with landfill liners suggests that contact between nonchlorinated organic liquids can cause the clay structure to compress, creating macropores in the clay and resulting in an increase in hydraulic conductivity of up to five orders of magnitude. If such a process occurs with chlorinated DNAPLs in the subsurface, then diffusion into the low-permeability regions may be enhanced, and advection (which is usually considered negligible) may be important as well. Furthermore, waste DNAPLs contain surfactants. If these surfactants diffuse into the low-permeability materials and are adsorbed to the mineral surfaces, the materials may become organic-wet, resulting in active imbibition of the DNAPL.

This project includes:

- Evaluating the impact of the contact between DNAPLs and clay on the storage in and the transport into and out of low permeability regions
- Evaluating the changes in clay structure due to the contact with DNAPLs
- Measuring the ensuing enhancement of transport into low permeability regions and examining the implications for site management under various scenarios
- Developing flow and transport numerical models associated with deformation of porous media, applying simulation model to assess real site remediation

Products

Huang, J., M. Goltz, A. Demond, and D. Ayral. (2009). “Transport of Organic Solutes in Clay Formations (PDF).” (19 pp, 496 KB) Presentation, American Geophysical Union 2009 Fall Meeting, San Francisco, California, December 14–18.

Principal Investigator

Junqi Huang
Hydrologist
580-436-8915