Characterization of Vertical Migration of PCE in a Granitic Aquifer Using Specialty Surface Geophysics

Todd Halihan (todd.halihan@okstate.edu) (Oklahoma State University, Stillwater, OK)
Stuart McDonald, P.E. (swm@aestusllc.com) (Aestus, LLC, Loveland, CO, USA)

Background/Objectives. A significant number of industrial facilities have had releases of perchloroethylene (PCE) in hard rock aquifers. These locations are difficult to investigate as porous media concepts for site characterization are often inappropriate. A specialty surface electrical resistivity method has been shown to detect PCE in sand aquifers, but in electrically resistive granitic aquifers, it was unclear if the method could detect changed induced by PCE. The selected study site is an industrial facility in Massachusetts with a very thin soil zone underlain by a granitic fracture aquifer. It was impacted by PCE at concentrations up to 100 parts per million (ppm) at depths up to 30 feet below ground surface (BGS). This study evaluated the use of this subsurface mapping technique to assess fracture mapping and direct detection of PCE distribution in the subsurface.

Approach/Activities. Thirteen transects were performed at the study site using an electrical resistivity imaging method (Aestus GeoTrax Survey™) designed specifically for use by the environmental industry. The electrical imagery provided drilling targets which were confirmed using groundwater geochemistry data from borings installed after imaging was completed.

2D and 3D integration and visualization of the geophysical subsurface imagery along with historical and confirmation drilling data yielded an interpretation of unweathered permanganate coincident with high resistive electrical anomalies within the resistive rock matrix. Electrically conductive anomalies were suspected to be indicative of ongoing biological activity. Electrical image data indicated resistive anomalies were dipping vertically downward in a linear fashion and away from the source area. The dataset contained linear electrically conductive features that appeared to follow fracture planes, but the resistive anomalies did not have the same geometry.

Results/Lessons Learned. The electrical resistivity of the granitic aquifer ranged from approximately 100-10,000 ohm-meters. Areas impacted by PCE were generally greater than 20,000 ohm-meters resistivity. Confirmation drilling and sampling indicated the highest concentrations of PCE at the site were located in a granite deformation band located within the rock body. This dipping linear feature began at 11 feet BGS and dipped linearly downward to 30 feet BGS within the granite body. Core samples of this zone appeared as gravel due to the rock competency and structure in this complex structural feature. The remaining lower level impacts followed fracture flowpaths delineated as conductive features extending through the geophysical dataset. This study indicated PCE can increase resistivity above the level of the surrounding rock body in highly resistive fractured rock aquifers.

This presentation will provide a detailed discussion of this site characterization work and how these results were utilized to enhance the conceptual site model (CSM) in preparation for targeted site remediation.