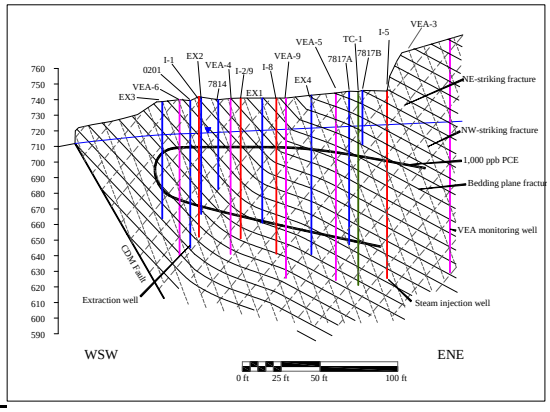

Project Title: "Steam Injection into Fractured Bedrock at Loring Air Force Base"

Principle Investigator: Eva Davis (USEPA/ORD/NRMRL/GWERD; Ada, OK 74820; 580-436-8548)

Collaborators: Maine Department of Environmental Protection, EPA Region I, SteamTech Environmental Services, Queens University, University of California – Berkeley, US Geological Survey

Introduction to the problem: Hundreds of contaminated sites exist where most or all of the subsurface contamination resides in fractured bedrock. Due to the complexity of the hydrogeologic systems in fractured bedrock, few remediations have been attempted.

Background: Over 450 drums that contained spent solvents were disposed of in the Loring AFB Quarry. Groundwater sampling below where the drums had been buried revealed groundwater contamination from leaking drums consisting of mostly tetrachloroethene (PCE). A research project was undertaken on steam injection remediation in fractured rock.

Objectives: 1) Determine if steam injection can be used to heat fractured bedrock 2) Determine if steam injection can enhance the recovery of volatile contaminants from fractured limestone, 3) Evaluate changes in rock and groundwater concentrations due to the steam injection, 4) Evaluate horizontal and vertical migration of contaminants from the treatment zone during steam injection, 5) Evaluate the use of electrical resistance tomography and borehole radar tomography to track steam/heat fronts in fractured limestone

Approach: Site characterization activities including sampling of rock to determine contaminant concentrations, discrete interval transmissivity testing, and discrete interval groundwater sampling was carried out and interconnectivity testing was performed. Based on all of the characterization data, a steam injection, extraction and monitoring system was designed and constructed. Steam injection was initiated in September 2002, and continued for approximately 80 days. Concurrently vapors and groundwater were extracted and analyzed. After steam injection was complete, 3 rounds of post treatment groundwater samples were obtained, and post treatment rock chip samples were obtained.

Accomplishments: Steam injection rates were lower than initially anticipated due to low permeability of the fracture network, however, effluent sampling during the steam injection showed that aqueous and vapor phase concentrations increased starting about three weeks after steam injection was initiated. Although effluent concentrations continued to increase throughout the 80 days of the steam injection, steam injection had to be halted due to lack of sufficient funding. Had we been able to complete the remediation, it appears that significant additional recoveries would have been possible. Groundwater concentrations in the area that received the most steam were reduced in the post treatment samples, however, in other areas concentrations increased. The post treatment rock chip samples seem to show an overall decline in contaminant concentrations in the rock. Groundwater sampling indicates vertical and hydraulic migration did not occur. The characterization and steam injection data allowed us to evaluate the usefulness of different types of characterization data for remediation in fractured rock.

Final Report: The final report is available for downloading from the website:
http://www.epa.gov/ORD/NRMRL/pubs/540r05010/540r05010.htm