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Background/Objectives. Characterization of dense non-aqueous phase liquid (DNAPL) source zone architecture is essential to develop accurate site specific conceptual models, delineate and quantify contaminant mass, perform risk assessment, and select and design remediation alternatives. The activities of a distribution facility for perchloroethene (PCE) and trichloroethene (TCE) at the Naverland site near Copenhagen, Denmark, has resulted in PCE and TCE DNAPL impacts to a fractured clay till and an underlying fractured limestone aquifer/bedrock. The scope of the investigations was to evaluate innovative investigation methods and characterize the source zone hydrogeology and contamination to obtain an improved conceptual understanding of DNAPL source zone architecture in clay till and bryozoan limestone bedrock.
Approach/Activities. A wide range of innovative and current site investigative tools for direct and indirect documentation and/or evaluation of DNAPL presence were combined in a multiple lines of evidence approach.
Results/Lessons Learned. Though no single technique was sufficient for characterization of DNAPL source zone architecture, the combined use of membrane interphase probing (MIP); coring with quantitative subsample analysis, SudanIV test, and PID; and NAPL FACT FLUTe gave good insight in the source zone architecture in the clayey till. Surface geophysics with ground penetrating radar (GPR) and seismic reflection and refraction combined with geologic information supplemented the conceptual understanding of transport and distribution of DNAPL in the fill and clayey till and the interface to the limestone. Core loss in the limestone, particulary from soft zones in contact with flint beds, was caused by the water flush applied during drilling and likely also resulted in loss of DNAPL from high permeability features. Hence, coring and subsampling for quantitative analysis and SudanIV tests continues to be an unresolved challenge in limestone. The coring may also have impacted DNAPL in high permeability zones near the borehole, thereby, potentially affecting the use of the NAPL FLUTe. Water-FLUTe multilevel groundwater monitoring and sampling (under two flow conditions) and FACT-FLUTe sampling and analysis provided important information regarding potential presence of DNAPL versus dissolved and sorbed phase contamination in the limestone matrix. These combined methods provided an improved conceptual understanding of DNAPL source zone architecture in fractured limestone. The DNAPL source zone architecture in the clay till was consistent with conceptual expectations. In contrast the documentation for and quantification of DNAPL in the limestone aquifer was limited and demands refinement of techniques and further characterization.