

Multiphase fluid flow modeling of chlorinated solvent infiltration in fractured clay till

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1. Background and objectives

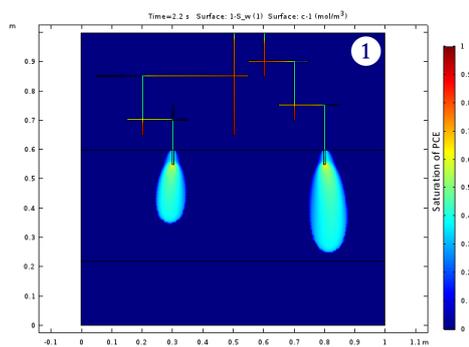
- The pollution of organic solvents in a clay-rich, fractured media such as clay till poses a serious threat to groundwater quality.
- The fracture network acts as a main pathway for DNAPL infiltration but water held in the clay due to capillary pressure enables dissolution and diffusion of DNAPL in the matrix.
- The primary objective of this study is to model the release of tetrachloroethylene (PCE) from fractured-clay system to the underlying aquifer to decipher which processes are driving water pollution through time.

3. Results

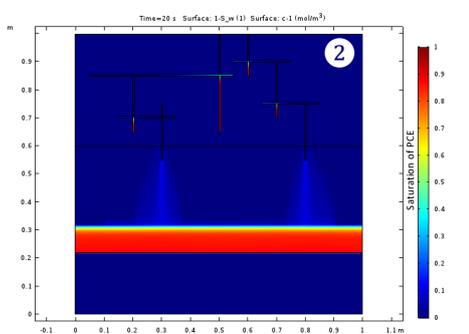
- The model predicts the infiltration of 63 kg/m of tetrachloroethylene.
- It shows the entry, persistence and exhaustion of DNAPL in the subsurface. Its evolution consists of four stages (Figs. below).

2. Working hypotheses

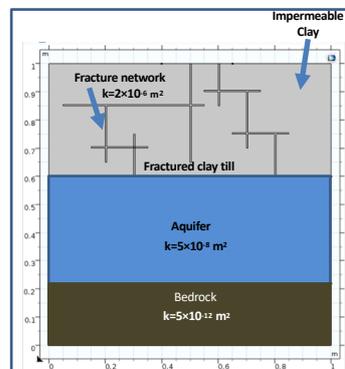
- A dual porosity single permeability two-phase flow model is built to study the fate of PCE in small-scale domain.
- The model assumes that the matrix in the fractured clay system is impervious and saturated with capillary water.
- The model geometry represents two domains: vadose zone having fracture network and impermeable matrix both underlain by a sandy aquifer.
- Brooks-Corey relationship was used for defining capillary pressure and relative permeability as function of fluid saturation.
- COMSOL Multiphysics 5.3. has been used to solve the partial differential equation for mass conservation.



The DNAPL plume displaces water from both vertical and horizontal fractures. The plume infiltrates into the aquifer before settling on the bedrock.

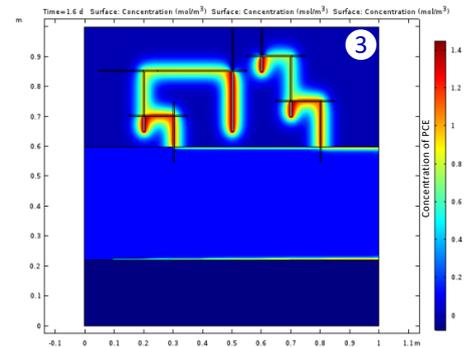


At the later stages, the DNAPL in the secondary source dissolves and gets diffused through the matrix. The low solubility of the DNAPL accumulated at bedrock makes the contamination persistent.

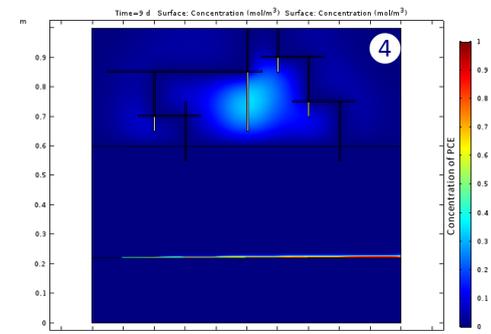


Model properties

- Fracture aperture: 5mm
- Water-saturated subsurface
- No diffusion at earlier stage
- DNAPL pressure of 3 cm height
- Saturation of DNAPL source: 0.6



When the DNAPL source is removed from the top, the DNAPL in vadose zone and aquifer settles on the bottom. However, the contaminant in the fracture remains intact forming a secondary source.



At the final stage the contaminant diffused in the matrix undergo back-diffusion

5. Acknowledgements

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