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Biologically mediated abiotic degradation of chlorinated solvents using Fe-bearing clay minerals

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Biological degradation of chlorinated solvents has been studied in some detail, whereas much less is known about abiotic degradation of widespread anthropogenic contaminants such as tetrachloroethene (PCE) and trichloroethene (TCE). Of particular interest for the treatment and remediation of these contaminants are abiotic processes that are stimulated by biological activity because they would provide the potential for sustainable monitored natural attenuation. In subsurface environments, microbially generated aqueous Fe(II) is abundant and we have demonstrated that when aqueous Fe(II) sorbs to clay minerals, electrons can be transferred to structural Fe in the clay mineral. The resulting electron-doped clay minerals may be redox active and might act as electron donors towards contaminants such as PCE and TCE.

To determine whether Fe(II)-containing clay minerals can reduce PCE and TCE, we carried out experiments with chemically reduced and Fe(II)-reacted clay minerals. We quantified both reactants and products using gas chromatography (GC-MS, GC-FID) and monitored changes in concentration over time periods of up to 12 months. We used a range of clay minerals, containing different structural Fe contents between 0 and 22 wt% to investigate the role of structural Fe content on chlorinated solvent degradation. To date we have detected no degradation products in reactors containing either fully chemically reduced clay minerals or Fe(II)-reacted clay minerals over a time period of 12 months. However, at high aqueous Fe(II) loadings, we observed precipitates in clay mineral-free reactors and confirmed the presence of $Fe(OH)_2$ using Mössbauer spectrometry. In these reactors, both PCE and TCE were degraded via a reductive β-elimination pathway, yielding small amounts of acetylene. We are currently investigating whether similar or other precipitates formed in the presence of clay minerals and how they affect the reductive transformation of contaminants.