

## Bench-Scale Evaluation of the Formation and Reactivity of Iron Sulfide Minerals for Treatment of CVOCs

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**Background/Objectives.** Reactive iron sulfide minerals may be formed in situ under sulfate reducing conditions in the presence of iron and a source of sulfur. This effect has been observed during the application of traditional in situ chemical reduction (ISCR) and anaerobic bioremediation substrates at sites with naturally high sulfate concentrations in groundwater, but may also be engineered by directly applying the needed building blocks. A key advantage of generating reactive minerals *in situ* as opposed to directly applying minerals or zero-valent iron (ZVI) as solid particles would be the potentially much larger surface area generated, where soil particles would be coated by a thin layer of reactive iron sulfide minerals. Abiotic degradation reactions occur in direct contact at the groundwater and ZVI particle / reactive mineral surface interface, which makes distribution critical. The goal with this study is to qualify and quantify the generation of reactive minerals in response to various substrate combinations, evaluating reactivity and overall CVOC degradation rates relative to the addition of organic carbon and ZVI substrates alone.

**Approach/Activities.** A series of batch reactors were set up with soil and groundwater impacted with TCE and amended with various substrate combinations composed of ZVI, organic carbon substrate, reduced minerals, ferrous iron, sulfide and/or sulfate. Both liquid and solid reagent combinations were evaluated. Overall degradation rates achieved were compared to systems amended with organic carbon substrate and ZVI only. At the completion of the study the mineral precipitation products formed will be collected and analyzed using sequential extraction analyses and its reactivity will be analyzed and compared against ZVI and commercially available reduced iron mineral products.

**Results/Lessons Learned.** Although early results indicate that ferrous iron minerals have a lower reactivity and reduction potential compared to some ZVI products, its significantly larger surface area and distribution properties makes it an important mechanism for in situ remediation applications. Electron microprobe analyses performed on iron sulfide precipitation products collected one year after the application of organic substrate and ferrous iron to a high sulfate aquifer showed that each 1.0 L of groundwater with sulfate at 3,000 mg/L reduced to an estimated 3.0  $\mu\text{m}$  thick FeS precipitates will yield about 1.2  $\text{ft}^2$  of very reactive surface.