

Documenting In Situ Reactive Iron Mineral Formation without Drilling: A New Monitoring Well-Based Sampling Approach

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Background/Objectives. The degradation of chlorinated methanes, ethanes, and ethenes by the reducing power stored in reactive minerals (e.g., magnetite, iron sulfides, etc.) is a subject of much active research (e.g., Whiting et al. 2014, He et al. 2015). However, cost-effective tools to evaluate and document these treatment processes in field applications are currently limited. While the analytical techniques to characterize reactive minerals are well developed (USEPA, 2009), and sample preservation methods for reactive minerals formed in anoxic environments are established (Wilkin, 2006), collection of samples to evaluate in situ mineral formation means costly drilling is required. A simple and cost-effective approach for the collection of samples to directly confirm the formation of these reactive minerals in situ without the need for drilling is needed.

Approach/Activities. A novel approach to monitoring the formation and longevity of reactive minerals has been developed that provides direct evidence of reactive mineral formation within an aquifer matrix without the need for drilling. The Mineral Trap (or, Min-Trap™) is a passive sampling device that is deployed within a monitoring well. It consists of a non-reactive porous medium contained within a water-permeable mesh that is deployed inside a groundwater well and allowed to incubate over time. The non-reactive medium within the Min-Trap™ provides a carrier substrate upon which target minerals can form passively. Analysis of the solid phase media within the Min-Trap™ through chemical, microscopic, or spectroscopic means gives direct evidence of the formation of target minerals in situ while avoiding the high cost, health and safety risks, and technical and logistical challenges associated with traditional drilling-based sample collection.

Results/Lessons Learned. Laboratory testing was conducted to demonstrate the capture of reactive iron sulfide minerals within the Min-Trap's non-reactive matrix under iron and sulfate reducing conditions. Visual inspection of the Min-Traps following approximately two weeks of incubation in this simulated groundwater environment showed near complete coating of the Min-Trap's non-reactive media with black precipitate material. Analysis of the precipitate indicated the Min-Traps contained more than 400 milligrams per kilogram (mg/kg) of mackinawite (FeS, as indicated by the acid volatile sulfide [AVS] method) and around 100 mg/kg of pyrite (FeS₂, as indicated by chromium extractable sulfide [CrES] method). Scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) analysis was also performed, and results are pending. Based on the successful laboratory demonstration, in August 2018 Min-Traps were deployed as part of a full-scale EHC™ injection program for treatment of chlorinated methanes, at monitoring wells within and outside the injection area to document in situ reactive mineral formation as a result of EHC™ injection. Full scale EHC™ treatment (274,000 lbs EHC™ via almost 300 injection locations) was completed in August 2018, and analysis of reactive mineral formation within both Min-Traps™ and confirmatory soil core samples using AVS/CrES and SEM-EDS techniques will be conducted in September 2018. The Min-Trap™ is an innovative technique developed to fill a fundamental need for evaluating the in situ precipitation of minerals

without the need for repeated and costly drilling efforts – a significant addition to the monitoring toolbox. This low cost, monitoring well-based approach can document reactive mineral formation in situ, providing conclusive data to evaluate degradation capacity, support remedy optimization, and facilitate natural attenuation evaluations.