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Reactive Iron Mineral Coatings in Redox Transition Zones and Their Impact on Natural Attenuation

Lisa Axe
New Jersey Institute of Technology

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Reactive iron mineral coatings play an important role in contaminant attenuation in redox transition zones at sites with subsurface contamination. An anaerobic 60 foot core was collected from the Chambers Works Site in Deepwater, NJ. Working in a glovebox, two-inch subsamples were used to evaluate redox transition zones using bulk composition, redox potential, pH, VOCs in the headspace, as well as abundant bacteria. A number of redox transition zones were identified and further studied with a suite of complementary analyses to characterize the surface chemistry. Analyses have included sequential extraction (phases and speciation), x-ray diffraction (mineralogy), x-ray fluorescence (composition), field-emission scanning electron microscopy (surface morphology down to the nm scale) with energy dispersive analysis (surface composition), and bench-scale experiments. Results reveal a clear trend in reactive iron (II)/(III) mineral coatings throughout transition zones. Reactive iron mineral coatings reveal iron (II) minerals pyrite, mackinawite, pyrrhotite, and siderite in a transition zone running through an aquitard. Ferrihydrite, goethite, and lepidocrocite were dominant iron (III) minerals in a transition zone that was observed in an aquifer, while pyrite, greigite and gypsum were the most abundant mineral coating in an upper aquitard transition zone. Overall, the most significant reactive mineral coatings were observed in redox transition zones located in aquitards where there is Fe$^{2+}$/Fe$^{3+}$ cycling. Ongoing studies are focused on abiotic degradation pathways for halogenated solvents present in the system.