Toward Optimized Bioclogging and Biocementation Through Combining Advanced Geophysical Monitoring and Reactive Transport Modeling Approaches

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Bioclogging and biocementation offer exciting opportunities for solutions to diverse problems ranging from soil stabilization to microbially enhanced hydrocarbon recovery. The effectiveness of bioclogging and biocementation strategies is governed by processes and properties ranging from microbial metabolism at the submicron scale, to changes in pore geometry at the pore scale, to geological heterogeneities at the field scale. Optimization of these strategies requires advances in mechanistic reactive transport modeling and geophysical monitoring methodologies. Our research focuses on (i) performing laboratory experiments to refine understanding of reaction networks and to quantify changes in hydrological properties (e.g. permeability), the evolution of biominerals and geophysical responses (focusing on seismic and electrical techniques); (ii) developing and using a reactive transport simulator capable of predicting the induced metabolic processes to numerically explore how to optimize the desired effect; and (iii) using loosely coupled reactive transport and geophysical simulators to explore detectability and resolvability of induced bioclogging and biocementation processes at the field scale using time-lapse geophysical methods. Here we present examples of our research focused on three different microbially-mediated methods to enhance hydrocarbon recovery through selective clogging of reservior thief zones, including: (a) biopolymer clogging through dextran production; (b) biomineral clogging through iron oxide precipitation; and (c) biomineral clogging through carbonate precipitation. We will compare the utility of these approaches for enhancing hydrocarbon recovery and will describe the utility of geophysical methods to remotely monitor associated field treatments.