Kinetics of microbial Fe(III) oxide reduction in freshwater wetland sediments

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ABSTRACT: The kinetics of microbial amorphous Fe(III) oxide reduction was investigated in sediments from a freshwater wetland in north central Alabama, USA. Fe(III) oxide concentrations decreased exponentially with time during anaerobic incubation of sediment slurries and homogenized surface sediments. Rates of organic carbon mineralization ($\Sigma SCO_2 + CH_4$ accumulation) did not change markedly during the course of Fe(III) oxide reduction, which indicated that the exponential decline in Fe(III) oxide concentration over time resulted primarily from Fe(III) limitation rather than a decrease in organic matter decay rate. Initial rates of Fe(III) oxide reduction were linearly correlated with initial Fe(III) oxide concentrations in experiments with mixtures of Fe(III)-rich and Fe(III)-depleted sediment slurries. Similar results were obtained in experiments with sediment from various depth intervals in the upper 3 cm of freshly collected cores. These findings provide explicit evidence that microbial Fe(III) oxide reduction rates are first order with respect to amorphous Fe(III) oxide concentration in the wetland sediment. The observed first-order relationship between Fe(III) oxide concentration and reduction rate is consistent with established models of surface area-controlled mineral transformation. An experiment in which Fe(III) oxide-rich sediment slurries were amended with different amounts of labile organic matter demonstrated a direct correlation between first-order Fe(III) reduction rate constants and initial rates of organic carbon mineralization. These results provide empirical support for existing approaches to modeling organic matter decay-dependent Fe(III) oxide reduction kinetics in sediments.

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