Imprints of thermodynamic constraints on microbial carbon oxidation in floodplains

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The thermodynamic implications of redox conditions on organic matter decomposition and C sequestration are undervalued in current predictive modeling efforts. Here we show conclusive evidence of changes in carbon chemistry as an effect of redox conditions. This strongly supports the idea that thermodynamic constraints regulate microbial metabolic activity with important implications for C decomposition and the coupled cycling of nutrients (e.g. S, N, P, Fe) and contaminants (e.g. U).

In a regional investigation of organic matter composition in relation to metal and nutrient cycling within floodplains of the upper Colorado River Basin, we observed distinct changes in the soluble carbon chemistry within reducing, organic-rich sediments compared to the (sub)oxic surrounding materials. This effect was not manifested in the bulk organic matter and could not be directly attributed to differences in source material. Rather, it indicated that metabolic constraints on organic matter decomposition imposed by the redox conditions resulted in preferential depletion of more oxidized organic compounds (e.g. carbohydrates, lignin) in the soluble fraction, leaving behind reduced carbon substrates (e.g. lipids) that are thermodynamically restrictive for microbial metabolism when coupled to iron or sulfate reduction. Our data further show strong correlations between C, Fe, S and U redox chemistry, which fits within the thermodynamic limitation framework. Our work supports a contention that thermodynamic constraints should be incorporated in future modeling of C decomposition and projections of metal fate and transport.