Role of iron in dissolved organic carbon degradation in the Arctic

ROSE M. CORY*[1], ADRIANNA TRUSIAK[1], COLLIN P. WARD[2], GEORGE W. KLING[3], VINCENT NOËL[4], JOHN R. BARGAR[4]

[1]Earth and Environmental Science, University of Michigan, Ann Arbor, MI, 48109, USA, *correspondence: rmcory@umich.edu

[2]Woods Hole Oceanographic Institution, Dept. of Marine Chemistry and Geochemistry, Woods Hole, MA, 02534, USA

[2]Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI, 48109, USA

[3]Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Laboratoy, Menlo Park, CA, 94025, USA

The cycling of iron and carbon are closely linked in Earth's critical zone where redox reactions of iron can limit or enhance the degradation of soil organic carbon to carbon dioxide (CO_2). For example, as reduced ferrous iron (Fe(II)) is oxidized by oxygen (O_2) to ferric iron (Fe(III)), reactive oxygen species such as hydroxyl radical (•OH) are produced. •OH can oxidize dissolved organic carbon (DOC) to CO_2 and to small organic acids that may fuel microbial respiration. We showed that iron-mediated oxidation of DOC in arctic soil waters may be an important component of the arctic carbon budget. Waterlogged arctic soils contain 100s of µM to > 1 mM of Fe(II). Introduction of O_2 to Fe(II)-rich soil waters triggered production of •OH, and subsequent oxidation of DOC to CO_2 in proportion to •OH produced. The •OH produced by iron redox cycling in soils may oxidize as much DOC to CO_2 as does microbial respiration of DOC in arctic surface waters draining soils. Iron's influence on carbon cycling in the Arctic likely extends across the critical zone from dark soils to sunlit surface waters. As iron and DOC are flushed from soils to surface waters, iron enhances the sunlight-driven (photochemical) oxidation of DOC to CO_2. For example, photochemical reactions of iron and DOC also lead to •OH production, and subsequent oxidation of DOC to CO_2. In addition, a close chemical association between iron and DOC (i.e., iron complexation) may catalyze the photochemical oxidation of organic acids within DOC to CO_2. These 'abiotic' consequences of iron redox cycling for the fate of organic carbon in the critical zone are just beginning to be understood. With every indication that climate change will continue to thaw organic carbon currently frozen in permafrost soils, understanding the role of iron in the oxidation of DOC to CO_2 in this critical zone is needed to predict the fate of frozen soil carbon in a warming world.