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Formation and reactivity of iron-organic matter (Fe-OM) phases in wetland systems

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The biogeochemical cycle of iron is closely linked to organic carbon turnover in soils, sediments, and aquatic environments. Association with iron (Fe) species has been observed to protect organic carbon (in the form of organic matter, OM) from microbial decomposition and eventual release as CO_2. In addition, this association changes the redox properties of iron, affecting its bioavailability. Iron-organic matter (Fe-OM) phases may form via sorption of dissolved or particulate organic matter (DOM and POM, respectively) to iron species, or formation of iron (oxyhydr)oxide minerals in the presence of DOM and/or POM.

The association between iron and organic matter is particularly important in wetland systems, e.g., peatlands, as they contain large quantities of organic carbon. These systems undergo redox changes through water table fluctuations. Under wet conditions, microbial iron(III) reduction may occur, leading to the release of associated organic matter which may then be available for microorganisms. Conversely, under dry conditions, abiotic oxidation of iron(II) due to O_2 may occur, reforming Fe-OM phases. Thus, the redox reactivity of Fe-OM phases has direct implications for the bioavailability of organic carbon in these carbon-rich systems. To better predict the turnover of carbon, it is critical to know (i) the quantity and composition of carbon and the speciation of iron within Fe-OM phases, and (ii) the reactivity of Fe-OM phases under changing redox conditions.

In this project, we investigate the formation and reactivity of Fe-OM phases in model and environmental systems. We first synthesized Fe-OM phases using peatland DOM and POM via different association pathways. We quantified the quantity of carbon and relative abundance of organic functional groups associated with these phases. Via X-ray absorption and Mössbauer spectroscopy, we characterized the iron speciation. Complementary to the laboratory experiments, we characterized Fe-OM phases from a permafrost peatland in Abisko, Sweden. We then subjected the laboratory and field Fe-OM phases to changing redox conditions and tracked the dynamics of iron and carbon. The results of this work will inform our understanding of the role of iron in organic carbon turnover in wetland systems.