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Organic carbon sorbed to reactive iron minerals released during permafrost collapse

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The release of vast amounts of organic carbon during thawing of high-latitude permafrost is an urgent issue of global concern, yet it is unclear what controls how much carbon will be released and how fast it will be subsequently metabolized and emitted as greenhouse gases. Binding of organic carbon by iron(III) oxyhydroxide minerals can prevent carbon mobilization and degradation. This “rusty carbon sink” has already been suggested to protect organic carbon in soils overlying intact permafrost. However, the extent to which iron-bound carbon will be mobilized during permafrost thaw is entirely unknown. We have followed the dynamic interactions between iron and carbon across a thaw gradient in Abisko (Sweden), where wetlands are expanding rapidly due to permafrost retreat. Using both bulk (selective extractions, EXAFS) and nanoscale analysis (correlative SEM and nanoSIMS), we found that up to 19.4±0.7% of total organic carbon is associated with reactive iron minerals in palsa underlain by intact permafrost. However, during permafrost collapse, the rusty carbon sink is lost due to more reduced conditions which favour microbial Fe(III) mineral dissolution. This leads to high dissolved Fe(II) (2.93±0.42 mM) and organic carbon concentrations (480.06±34.10 mg/L) in the porewater at the transition of desiccating palsa to waterlogged bog. Additionally, by combining FT-ICR-MS and greenhouse gas analysis both in the field and in laboratory microcosm experiments, we are currently determining the fate of the mobilized organic carbon directly after permafrost collapse. Our findings will improve our understanding of the processes controlling organic carbon turnover in thawing permafrost soils and help to better predict future greenhouse gas emissions.