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Complex Effects of Redox Reactions on the Release and Degradation of Organic Carbon

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Recent studies have suggested the potential for the release of iron (Fe) oxides-bound organic carbon (OC) during dissimilatory Fe reduction (DIR). However, the extent to which different forms of Fe oxide-bound (e.g. sorbed vs. co-precipitated) OC are released during DIR has not been fully resolved. Pure ferrihydrite (Fh) and Fh-humic acid coprecipitates (Fh-HA) were inoculated with a small quantity of freshwater sediment and incubated under anoxic conditions in the presence and absence of H₂ or glucose as electron donors for DIR. Our results indicate that DIR can release loosely bound (e.g. sorbed) OC but may not from Fe oxide-OC coprecipitates.

Applying Fourier transform ion cyclotron resonance mass spectrometry (FTICR-MS), we investigated the fractionation of dissolved organic carbon (DOC) during co-precipitation with Fh in systems with C/Fe molar ratio of 0.5 and 3. Our results showed that high-molecular-weight DOC was preferentially precipitated for system with C/Fe of 3. In addition, a higher fraction of condensed polycyclic aromatic hydrocarbons (98.12%) was co-precipitated compared to unsaturated phenolic (66.25%) and aliphatic (39.01%) DOC. Our findings demonstrated that high-molecular-weight aromatic compounds preferentially co-precipitate with Fh in systems with feed C/F ratio relevant to the natural systems.

In the field, year-round measurements of ecosystem-scale methane and carbon dioxide fluxes were undertaken at Toolik Field Station in the Alaskan Arctic over two years. Year 1 cold season net carbon dioxide and methane fluxes, however, were 47 % and 150 % higher, over a shorter cold season (22 days shorter). Relationships between methane fluxes and surface temperatures were almost reversed to Year 2, though similar relationships between respiration fluxes and surface soil temperature were observed across both years. Our results suggest that high cold season methane emissions are linked to temperature thresholds in deep, active layer zones and highlight a need for measurement and modelling of soil temperatures throughout the year and entire active profile in order to better predict potential changes in the annual methane exchange budget in Arctic tundra regions.