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Biogeochemical Release and Reactions of Iron-Bound Organic Carbon During the Redox Processes

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Iron (Fe)-bound organic carbon (OC) contributes an important component in the global cycles of OC. In this project, we have systematically studied the biogeochemical reactions of Fe-bound OC during the redox processes.

We have investigated the release and transformation of synthesized Fe-OC complexes during the abiotic and biotic reduction. During the abiotic reduction, hematite-bound OC was released more rapidly compared to the reduction of Fe, and aliphatic OC was more resistant to the reductive release than other components of OC. In the microbial reduction, reduction of ferrihydrite (Fh) and reductive release of Fh-bound OC were governed by the C/Fe ratio, with higher C/Fe ratio enhancing the Fe reduction and release of Fe-bound OC. In addition, we synthesized Fh coprecipitated with model OC, including glucose (GL), glucosamine (GN), tyrosine (TN), benzoquinone (BQ), amylose (AM), and alginate (AL). During the 25-d reduction by *Shewanella putrefaciens* CN32, the reductive release of OC followed the order Fh-BQ > Fh-GN > Fh-TN > Fh-GL > Fh-AL ≈ Fh-AM. OC regulated the reduction of Fh through acting as an electron shuttle and affecting the bacterial activity. Our results showed that the Fe reduction and release of Fe-bound OC were governed by the mineral phase of Fe oxide, C/Fe ratio, and chemical composition of OC.

For natural forest soils, Fe-bound OC contributed about 38% of total OC in forest soils. The anaerobic release of OC was closely related to the microbial reduction of Fe. When soils were transferred to aerobic conditions, the mineralization of OC was substantially inhibited compared to soils without pre-reduction. The OC was sequestered potentially through the co-precipitation with Fh formed during the oxidation of Fe(II). Oxidation of Fe(II) by O₂ led to the generation of OH radicals, which dominated the abiotic oxidation of OC. These findings provide a novel insight into the role of redox reactions in the biogeochemical cycles of OC. We also have monitored the seasonal dynamics of CO₂ and CH₄ for tundra soils at Toolik site, and analyzed the microbial community in these soils through 16S rRNA analysis.

Through experimental studies on the synthesized complexes and natural soils, our results uncover the coupled dynamics of Fe reduction and OC transformation, i.e. the release of OC during anaerobic reduction and inhibited mineralization under aerobic conditions. For the next step, we plan to study the long-term respiration of Fe-bound OC under different temperatures and transformation of different functional groups during the redox processes.