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Increased Silicon Availability in Fen Peat: Dissolution of Fe-Phosphates and Changes in DOC Quality under Oxic Conditions

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A recent study showed elevated carbon dioxide (CO_2) and methane (CH4) concentrations in peatland soils under increased Silicon (Si) availability. In another recent study, Si was furthermore shown to mobilize nutrients such as phosphorus (P) into the soil solution of permafrost soils by dissolution of iron (Fe)-phosphates. The mechanism is conjectured either to be found in the dissolution of Fe-phosphates releasing P into the soil solution which stimulates microbial respiration or in a direct influence of Si on the organic matter quality which in turn would have the same effect.
To elucidate possible causes of these observed effects, we conducted incubation experiments under addition of Si and / or iron oxyhydroxides (FeOOH) and measured CH4 and CO_2 formation rates. In another batch experiment we added amorphous Si to fen peat material and incubated this for two days on a rotating shaker. The suspended organic matter was then used for an X-ray absorption spectroscopy (XAS) analysis at the C1s and the Fe2p edge.
We hypothesized that [I] there is a difference in the effects on respiration rates between oxic and anoxic conditions, entailing the existence or absence of oxidized Fe respectively. Moreover we expected [II] a higher concentration of P and Fe and dissolved organic carbon (DOC) under high Si availability caused by dissolution of colloidal Fe-phosphates and [III] changes in the DOC quality, which might explain or instead be explained by the differences in respiration measured under field conditions in another study.
We did not find any effect of Si addition under strictly anoxic conditions, however significantly higher CO_2 and CH4 respiration rates under initially oxic conditions. In the two day experiment significantly higher concentrations of P and Fe and marginally not significantly higher concentrations of DOC were found. Using XAS we assume a dissolution of Fe-phosphates and a change in the organic matter quality that is to say smaller peak areas of quinones and carboxyl-groups under high Si availability. A hypothetical model of explanation was developed: Si leads to a fast dissolution of Fe-phosphates, thereby increases the nutrient availability in the incubations and thus leads to an increased degradation particularly of oxidized parts of the OM like quinones and carboxyl-groups.