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Geochemical and microbiological variations along vertical redox gradients in a seasonally flooded sub-Arctic wetland

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A large proportion of global carbon is stored in northern high-latitude soils [1], and reactive iron minerals, known as a 'rusty sink' for organic carbon, play an important role in carbon dynamics in the Arctic [2]. As the global temperature rises and the permafrost thaws, sub-Arctic soils are facing more dramatic seasonal water level fluctuations, resulting in strong impacts on iron mineral stability and structure of the associated microbial community and in turn the cycling of organic matter and phosphorus. Studies to date have shown that following redox fluctuations more crystalline iron minerals formed/transformed, leading to the release and consumption of organic carbon [3-5]. However, few studies have characterized the chemical, mineralogical and biological differences in sub-Arctic soils at the bulk and molecular scales in response to changes in redox potential. Here, we evaluated mineralogical and microbiological changes in seasonally water-logged soils in south Iceland along the vertical redox gradient. Using various chemical extractions we determined the partitioning and distribution of organic carbon, phosphorus and iron in the soil horizons. Combining these results with detailed mineralogical (X-ray diffraction), chemical (X-ray fluorescence), spectroscopic (scanning transmission X-ray microscopy) and microbiological analyses (16S rRNA) analysis, we document that the redox transition zone is clearly distinct from the other layers in terms of iron, phosphorous and organic carbon composition, speciation and structure. Our results provide new insights into seasonal redox processes that affect the fate of carbon/phosphate-associated iron minerals in the sub-Arctic and how this happens through subsurface reactions at mineral- microbe interfaces.

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