Weathering and pore water evolution in the foreland of retreating glacier, SW Spitsbergen

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Chemical weathering and soil forming processes which are associated with retreating glaciers contribute to high chemical denudation observed in polar regions. Retreating glaciers uncover fresh regolith, initial evolution of which may be dominated by few simple processes. The area of this study is the foreland of Werenskiold glacier near SW coast of Spitsbergen. This glacier has been countinuously retreating during the last century by several meters a year [1]. The objective of this study is correlation between the chemistry of pore waters and the mechanisms of alternation or dissolution of minerals present in regolith with respect to the distance from the glacier front (age of exposure). This is a part of large research effort on weathering, soil formation and initial microbiological activity on a foreland of Arctic glacier initiated with the International Polar Year in 2007.

Werenskiold glacier basin is eroded in metamorphic rocks which belong to Precambrian Hecla Hoek Succession. These are mostly carbonates, quartzites, phyllites, shists, greenshists and amphibolites [2]. In accordance with other studies, the carbonate dissolution dominates in the youngest glacial sediments while silicate weathering is relatively significant in the oldest sediments. The composition of water can be explained mostly by dissolution/crystallization accompanied with redox reactions. Alterations of minerals identified with optical microscopy, XRD and SEM-EDS include dissolution of carbonates and oxidation of pyrite accompanied with formation of clays. Systematic changes between water samples correlate with distance from the glacier front (with the age of soils): e.g. the pH decreases from 8, 6 to 7, 7 while TDS increases from 133 to 748 mg/L. Inverse modeling with PHREEQC was used to propose the mechanisms of mineral transformation. The waters evolve from carbonate-dominated to sulfate-dominated. This might indicate that with time, pore waters reach the equilibrium with carbonate minerals while being countinuously supplied with SO_4^{2-} from sulfides oxidation.

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[1] Bukowska-Jania (2007) *Pol. Polar Res.* **28**, 137–155.
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Roles of sulfate and Fe^{III} reduction on microbial community development

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To better understand the roles of sulfate- and/or iron-reduction on microbial community development, bicarbonate-buffered batch systems were created with acetate or lactate as the electron donor. Added electron acceptors included 2-line ferrihydrite, goethite, or lepidocrocite, in the presence or absence of sulfate. The batch systems were inoculated with the native microbial community present in a subsurface sediment. The rate of Fe^{III} reduction was low in the absence of sulfate. However, the rate and extent of Fe^{III} reduction increased more than 10 times with 10 mM sulfate. Sulfate reduction occurred concurrently with Fe^{III} reduction suggesting abiotic Fe^{III} reduction by sulfide. X-ray absorption fine-structure (XAFS) analysis confirmed the formation of ferrous sulfide as the major secondary mineral phase in these incubations. The rates of sulfate and Fe^{III} reduction were significantly faster with lactate than with acetate. Lactate promoted both sulfate and Fe^{III} reduction in all incubations, while acetate stimulated sulfate and Fe^{III} reduction only in ferrihydrite and goethite incubations. Acetate oxidation was coupled with sulfate and Fe^{III} reduction; however, lactate was rapidly fermented to acetate and propionate, followed by propionate oxidation coupled with sulfate reduction. Terminal Restriction Fragment Length Polymorphism (T-RFLP) yielded unique microbial community profiles. The presence of sulfate resulted in distinct community development likely due to the proliferation of acetate- or propionate-utilizing, sulfate-reducing bacteria. During the experiment, the community in lepidocrocite incubations evolved in a very different way compared to those in the other Fe^{III} (hydr)oxide incubations indicating that the nature of the Fe^{III} (hydr)oxide can affect microbial community development. However, after the complete consumption of sulfate the microbial community compositions in all incubations (except lepidocrocite plus acetate incubation) were similar to each other. These results show that the availability of sulfate, the type of Fe^{III} (hydr)oxide present, and the added electron donor can have a strong effect on the development of subsurface microbial communities.