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Comparison of chemical weathering in the subglacial and sub-moraine conditions of two High Arctic glaciers (Svalbard)

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The aim of studies was to compare chemical weathering in the sub-moraine and sub-glacial conditions of two High Arctic glaciers (Werenskioldbreen and Ariebreen, Svalbard). Werenskioldbreen is a poly-thermal glacier with area c.a. 27 km^2 underlain by highly diversified rock (quartz conglomerates, phyllites, muscovite-carbonate-quartz schist) with low carbonate concentration (<5%). Ariebreen is small cold-based glacier with area 0.36 km^2 underlain by paragneisses and metapelities. Ice-cored moraine complex is situated in front of this glacier.

From August to September 2010, water samples were collected from upper inflow (10) and two outflows (20) from moraine complex in the Ariebreen basin. In the Werenskioldbreen, samples were collected from subglacial outflows - Kvisla river (2), Black Spring (4), Angell outflows (5), as well as supraglacial streams (5).

In Black Spring, pH was highest (mean 8.90) whereas, in river Kvisla and in Angell outflows, achieved 7.96 and 7.85, respectively. In outflows from Ariebreen moraine, mean pH was substantially lower (6.98) with wide parameter range (6.51-8.47). Mean water temperatures of outflows were lower in the Werenskioldbreen than in Ariebreen (0.26 and 0.54 ˚C respectively). Most of water temperatures in the former falls below 0.1 ˚C. Highest sum of cations was observed in Kvisla river and Ariebreen outflows (14.28 and 13.84 $mg{\cdot}L^{-1}$, respectively), whereas lower concentrations in the Black Spring and Angell outflows (9.11 and 7.23 $mg{\cdot}L^{-1}$, respectively).

Among cations, Ca^{2+} exhibits highest concentration in all sites and concentration order was as follows: Ariebreen outflows, Kvisla river, Black Spring, Angell outflows 0.470, 0.453, 0.301 and 0.247 $meq{\cdot}L^{-1}$, respectively. Remaining ions (Mg^{2+}, Na^{+}, SO_4^{2-}, Cl^{-}, NO_2^{-}) and silica reflect highest concentration in the Kvisla river and the Ariebreen outflows. Conversely, mean concentration of Fe is higher in all Werenskioldbreen outflows in compare with Ariebreen (0.0020 and 0.0013 $meq{\cdot}L^{-1}$, respectively). In addition, mean concentration of Na^{+} and Cl^{-} derived from all samples shows slightly higher values for former ion (0.080 and 0.076 $meq{\cdot}L^{-1}$, respectively). Moreover, in the Werenskioldbreen outflows, mean nitrate concentration tends to be significantly lower in compare with mean nitrite (0.003 and 0.029 $meq{\cdot}L^{-1}$, respectively). Otherwise in Ariebreen outflows, concentration of both anions remain similar (0.037 and 0.030 $meq{\cdot}L^{-1}$, respectively).

Water pH from upper inflow to Ariebreen moraine was substantially higher in compare with supraglacial streams of Werenskioldbreen (6.96 and 5.16, respectively). Moreover, sum of cations was higher in former against latter (5.86 and 2.63 $mg{\cdot}L^{-1}$, respectively) and, therefore, concentrations of most ions and silica were considerable higher. Calcium remains highest among cations with mean 0.047 and 0.012 $meq{\cdot}L^{-1}$ for Ariebreen and Werenskioldbreen, respectively. Potassium and SO_4^{2-} concentrations in Ariebreen inflow (0.0013 and 0.061 $meq{\cdot}L^{-1}$, respectively) were more than 10 times higher. Nitrite appears exclusively higher than nitrate in both basins. Iron concentration is higher in the supraglacial streams of the Werenskioldbreen than in the inflow of Ariebreen (0.0018 and 0.0012 $meq{\cdot}L^{-1}$, respectively).

Water from sub-moraine and sub-glacial outflows shows similar pattern in the light of predominating ions as well as total sum of cations, which is well-know indicator of chemical weathering. In addition, bedrock of Ariebreen basin is relatively more resistant than in the Werenskioldbreen, but concentration of ions tends to be quantitatively similar or even higher. Additionally, Ariebreen basin is substantially smaller in total area. Very low water temperatures and high discharges from Werenskioldbreen may inhibit chemical reactions and, in consequence, influence on lower ion concentration. Apart from this, based on comparison between supraglacial (or moraine inflow) and subglacial (or moraine outflows) water chemistry, more pronounced enrichment in solutes appears in the Werenskioldbreen basin. Nitrate deficit against elevated nitrite in subglacial outflows may relate to oxidation process, thereby nitrate becomes an oxidizing agent.