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Preliminary Geochemical Assessment of the Subglacial Environment of Beerenberg, the World's Northernmost Active Stratovolcano

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As loci of the fresh formation of alkaline rock, volcanic islands are hotspots of geochemical activity. Collectively volcanic islands are responsible for approximately one third of the global long term CO_2 drawdown from chemical weathering. Glaciers also form environments with substantial chemical weathering activity. Despite zero-degree temperatures, subglacial environments provide both freshly ground down mineral surfaces and highly dilute meltwaters, allowing chemical processes to occur at faster rates than in warmer settings where reactions occur near chemical saturation. Yet, the degree to which glaciation enhances weathering on volcanic islands has received relatively little study.

Beerenberg, Jan Mayen, Norway, is the world´s northernmost active stratovolcano. It is mostly glacierized, with 23 distinctly named glaciers descending from the top of the volcanic cone to the sea. Many of the Beerenberg glaciers release sediment-laden subglacial water, indicative of water-rock interaction in subglacial environments. In August 2021, we did a preliminary survey of the aqueous geochemistry and sediment composition of several subglacial outlets at Beerenberg's largest glacier, Sørbreen. We also surveyed glacial surface streams, glacial ice and snow, non-glacial melt streams, springs, and proglacial lakes.

The subglacial waters of Sørbreen are strongly enriched in bicarbonate, with little chloride despite the marine location and only trace amounts of other anions. Cation composition is ~60% Na and K and 40% Ca and Mg by mole, suggesting a balance between divalent and monovalent cations reflective of local bedrock. Together this strongly suggests carbonation weathering of silicate minerals as the source of the vast majority of dissolved load in the subglacial waters. Non-glacial waters are more dilute and enriched in sea water derived ions (Cl, SO_4, and Na) compared to subglacial waters.

While a complete geochemical budget is not possible from our initial observations, these results imply that Beerenberg is a hot spot of chemical weathering. If our dissolved CO_2 fluxes are representative of long-term averages, then atmospheric CO_2 drawdown at Sørbreen is comparable to other glacierized mafic volcanic rock regions, such as those on Iceland and Disko Island. These atmospheric CO_2 drawdown rates are approximately double the world average and a factor of five higher than the drawdown in non-glacierized high latitude regions.