Weathering in the forelands of two rapidly retreating alpine glaciers of volcanic bedrock in the Three Sisters, Oregon, USA

The glaciers of the Three Sisters volcanoes in Cascadia have retreated dramatically over the past century. In order to understand ongoing chemical weathering and solute transport in the proglacial valleys, waters were sampled from glacier outwash streams, local snowmelt, and proglacial springs and lakes at Collier and Diller Glaciers. To understand weathering and transport processes in the proglacial plains, infrared orbital remote sensing data was used to map compositional variability and highlight weathering products, which were then ground-truthed with laboratory mineralogical and chemical analyses of sediments.

The hydrochemistry is significantly affected by a sub- and proglacial mafic weathering system lacking carbonate minerals. Here we report major ion concentrations in meltwaters for the summer 2016 and 2017 melt seasons. Total cation concentrations range from 3 to 250 μeq/l and dissolved bicarbonate concentrations range from 2 to 200 μeq/l. Other dissolved anions are negligible compared to bicarbonate. Dissolved silica concentrations range from 2 to 260 μmol/l, comparable to total dissolved cation concentrations. The highest cation and silica concentrations were measured in moraine-sourced springs.

Compositional remote sensing analysis identified alteration zones in the proglacial plains at both Collier and Diller indicating potential hydrated silica. This analysis is consistent with laboratory analysis of sediment samples, which indicate the presence of poorly crystalline phases weathering products, including hydrated silica. Weathered materials are preferentially deposited on moraines due to aeolian and glacial transport, as well as intra-moraine alteration, and at abandoned stream terraces due to fluvial transport.

Geochemical measurements indicate that the predominant form of chemical weathering in these periglacial mafic systems is the carbonation of feldspar as well as reactive volcanic glass. The presence of poorly crystalline silicates, as indicated by remote sensing datasets and laboratory analysis, is consistent with rapid weathering of feldspars and glass and formation of Fe-Al-Si-bearing mineraloids in these proglacial valleys. This weathering regime has wide-ranging implications for atmospheric CO_2 drawdown due to cold-climate volcanic rock weathering.

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