



Glacial alteration of volcanic terrains: A chemical investigation of the Three Sisters, Oregon, USA.

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Glacial silica cycling is more efficient than previously reported, and in some settings, particularly glaciated mafic volcanics, can be the dominant weathering process. Based on field work at glaciated volcanic sites, we hypothesize that this is due to a combination of high rates of silica dissolution from mafic bedrock and reprecipitation of silica in the form of opaline silica coatings and other poorly crystalline silicate alteration phases.

The high rate of bedrock comminution in subglacial environments results in high rates of both chemical and physical weathering, due to the increased reactive mineral surface area formed through glacial grinding. In most bedrock types, carbonate weathering is enhanced and silica fluxes are depressed in glacial outwash compared with global average riverine catchment runoff due to low temperatures and short residence times. However, in mafic systems, higher dissolved SiO_2 concentrations have been observed.

The major difference between observed glacial alteration of volcanic bedrock and more typical continental terrains is the absence of significant dissolved carbonate in the former. In the absence of carbonate minerals which normally dominate dissolution processes at glacier beds, carbonation of feldspar can become the dominant weathering process, which can result in a high proportion of dissolved silica fluxes in glacial outwash waters compared to the total cation flux. Mafic volcanic rocks are particularly susceptible to silica mobility, due to the high concentration of soluble minerals (i.e. plagioclase) as compared to the high concentration of insoluble quartz found in felsic rocks.

To investigate melt-driven chemical weathering of mafic volcanics, water and rock samples were collected during July 2016 from glaciated volcanic bedrock in the Three Sisters Wilderness, Oregon, U.S.A. (44°9'N, 121°46'W): Collier Glacier (basaltic andesite, andesite), Hayden Glacier (andesite, dacite), and Diller Glacier (basalt). Here we report major anion and cation concentrations in meltwaters for the summer 2016 melt season, with emphasis on SiO_2 .

Dissolved silica concentration (range: below detectable levels to 240 μM) tends to increase with pH (range: 4.3 to 8.5), consistent with silica solubility increasing with pH. Proglacial streams, springs, and lakes exhibit dissolved silica concentrations that are greater than observed in glacial snow/ice. The highest silica concentrations were measured in moraine-sourced springs.

More mafic glaciovolcanic sites exhibit higher concentrations of dissolved silica in outwash waters compared to more felsic glaciovolcanic sites. Though basalts have lower SiO_2 content than more felsic volcanic rocks, they are more susceptible to silica mobility due to their higher content of minerals such as olivine, pyroxene, and plagioclase, which are more soluble than quartz. These mineral breakdown reactions are potentially enhanced by microbial populations at the glacier bed.

The measured high silica concentrations in springs are potentially due to moraines acting as sediment traps. Moraines are poorly sorted sediments with a high proportion of subglacially ground fine particles, and glacial flour further accumulates by aeolian deposition. The increased fine-grained component – and thus increased surface area – and longer residence times due to associated decreased permeability could contribute to the observed high dissolved silica concentrations.