Investigating Subglacial Environments at Mount Rainier, WA using Suspended Sediment Concentrations and Hydrochemical Analysis
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Abstract
We use hydrochemical and suspended sediment analysis of glacial meltwater from Mount Rainier, Washington to investigate subglacial environments, including hydrothermal influence, weathering and erosion processes, and sediment storage. Mount Rainier thermal springs contain high levels of sulfate and chloride; we interpret the presence of these anions in glacial meltwater as indicators of subglacial hydrothermal influence. In contrast, zones of subglacially supplied sulfate and chloride during diurnal lows in water discharge, when the supply of snowmelt to glacial meltwater is low. Data collected in the summers of 2012-2016 suggest that increased production of suspended sediment is associated with hydrothermally-altered bedrock beneath the glacier. Meltwater from Tahoma glacier, which originates from an area known to be hydrothermally altered, yields consistently higher levels of chloride and sulfate, and of suspended sediment relative to other glaciers. Additional analyses of other glacial meltwater from Mount Rainier. We expect meltwater from Tahoma and Emmons glaciers to contain relatively high levels of sulfate and chloride due to their proximity to hydrothermally-altered bedrock. We also hypothesize that suspended sediment concentrations will decrease toward the end of the ablation season due to the melting of subglacial pockets that store suspended sediment during the accumulation season. Our work will inform ongoing efforts to understand sediment transport and geologic hazard risk in Mount Rainier National Park.

Research Questions
1. How do suspended sediment vary throughout the ablation season in the glacial meltwater discharge from Emmons glacier, and does it reflect releases of englacial sediment storage?
2. From and suspended sediment data collected in the summers of 2012-2016, do areas of high suspended sediment concentration in glacial melt water exhibit subglacial hydrothermal alteration of bedrock on Mount Rainier?

Background
Mount Rainier is the tallest peak in the Cascade Range reaching 14,410 feet (USGS, 2015). The active stratovolcano is located in western Washington, 30-40 miles southeast of the Seattle-Tacoma metropolitan area (Figure 1). 25 named glaciers lie on the flanks of Mount Rainier (USGS, 2014). Due to extensive hydrothermal activity, the mountain contains a high potential for lahars or debris flows. Such events could reach the Puget Sound and affect the land, property, and resources in between (Wood and Souquet, 2009).

Meltwater is discharged from Mount Rainier glaciers throughout the ablation season. Diurnal discharge is dependent on daily temperatures and solar radiation, while subglacial discharge is reflecting of seasonal melt as well as characteristics of the glacier’s internal drainage system (Wiemer et al., 1998).

For this project, suspended sediment concentration (SSC) indicated relative amounts of subglacial erosion or release of subglacially stored sediment by means of glacial meltwater (Mull, 1979).

Chemical weathering, or erosion caused by chemical reactions, also occurs in the subglacial environment (Brown, 2002). Meltwater can accept the chemical signature of its environment as it flows through a hydrological path. Bedrock that has undergone hydrothermal alteration will display increased anion levels of SO4 and Cl. Decreased chloride and increased electrical conductivity levels are also indicative of hydrothermally influenced bedrock (Lawler et al., 1996).

Methods
Suspended sediment samples were collected in 500 mL sample bottles and filtered in the lab (Figure 4). Water volume and weight of the sediment were recorded to obtain a concentration of mg/L. Hydrochemical meltwater samples were similarly collected in the field, but were immediately transferred to a 500 mL vacuum-driven filter system to remove suspended sediment (Lawler et al., 1996). An ion chromatograph measured anions in 5 mL samples in the lab. Because they reflect a direct chemical signal of the hydrothermal system (Frank, 1995), samples of the Longmire hot springs were also collected, filtered, and analyzed in order to compare to the meltwater samples.

Measurements of the channel’s shape (Figure 5 and 6) and width, using a laser distance measure, or the channel were used to calculate an area of the channel’s cross-section. A HI 9828 Multiparameter was used to collect continuous pH and electrical conductivity measurements within the meltwater channel. A pressure transducer took continuous measurements of water depth; we later used this to represent the general shape of discharge.

Results
Figure 1: Map of Mount Rainier glaciers. Yellow circles indicate sites sampled from 2012-2016. Glacially-sourced meltwater was collected at all locations. Map created by Matthew Wood (from vision.colostate.edu)

Seasonal Suspended Sediment Concentrations Results at Emmons

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Discussion
• SSC per unit volume increased during times of increased discharge (Figure 10). Both SSC and discharge increased in afternoons/evenings and decreased in early mornings due to daily solar radiation and atmospheric temperature (Hock, 1999).
• Higher discharge on July 21-22 was due to sustained high temperatures and solar radiation (Figure 7).
• Higher SSCs were observed on July 21-22 despite lower discharge levels (Figure 7). This is indicative of new pathways in the englacial or subglacial drainage systems during mid-ablation season, flushing out collected sediment (Collins, 1990).
• Figure 8 and 9 show sulfate and chloride concentrations increasing with higher discharge, possibly due to an increase of meltwater-bedrock interaction (Brown, 2002).
• High sulfate and chloride are indicative of hydrothermal alteration (Lawler et al., 1996). 2015 Tahoma glacial meltwater contained the largest amounts of sulfate (Figure 8) consistent with hydrothermally altered bedrock beneath the glacier (Finn, 2001).
• Bedrock alteration at Tahoma could account for a 26% increase in maximum SSC in comparison to Emmons meltwater maximum SSC.
• Emmons glacier meltwater displayed low anion concentrations (Figure 8), suggesting little or no access to hydrothermally altered bedrock (Lawler et al., 1996).
• Emmons glacier covers the largest area (11.28 km^2) on Mount Rainier (Stinson et al., 2011). This could explain the high SSC within the meltwater.