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Chemical Weathering of Deposits from the 1980 Mount St. Helens Eruption and its Effect on Stream Water Chemistry

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Chemical Weathering of Mount. St. Helens Volcanic Sediments

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Introduction:

Mount St. Helens (MSH), located in Skamania County, Washington, is a composite or stratovolcano on the Cascadia Subduction Zone. The last major eruption occurred on May 18th, 1980 and is therefore relatively fresh in a geologic respect (Figure 1). The blast and overall eruption produced a massive empty crater, flattened surrounding forests through the force created by the blast that simultaneously ejected tephra, and created a pyroclastic flow down the north flank (Fisher, 1997; Decker and Decker, 1981; Peterson 1986). The blast covered the north flank of the volcano with new materials including ash, pumice and other volcanic rocks. Understanding the chemical weathering of the fresh pyroclastic rocks may provide insight into soil development, nutrient availability for plants, and stream water composition in newly formed landscapes.

Objectives:

To determine the relative resistance of different Mount St. Helens rock types (rhyolite, andesite, pumice, scoria, and granitoid) to chemical weathering which may help:

- Identify the presence of easily-weathered minerals such as calcite and apatite
- Examine how the chemical weathering of minerals will effect the stream water chemistry.

Importance of Chemical weathering

$$CO_2 + H_2O \xrightarrow{\text{yields}} H_2CO_3$$

This equation explains how carbon dioxide (Co_2) and water (H_2O) combined in the atmosphere to create carbonic acid (H_2CO_3), resulting in slightly acidic water.

$$CaSiO_3 + 2H_2CO_3 \xrightarrow{\text{yields}} Ca^{2+} + 2HCO_3^- + SiO_2 + H_2O$$

This equation illustrates the break down of wollastonite, a mineral commonly used to explain chemical weathering (B. Dupré et al, 2003). One molecule of wollastonite ($CaSiO_3$) reacts with two molecules of carbonic acid (H_2CO_3), to make one molecule of calcium Ca^{2+}, two molecules of bicarbonate (HCO_3^-), one molecule of silicon dioxide (SiO_2), and one molecule of water (H_2O).

Methods:

- Sediments were collected from multiple streams in the pyroclastic zone on the north flank of the volcano (Figure 1).
- The sediments were analyzed in two ways:
  - Fine grain samples from each location were sieved to <2mm.
  - Gravel-sized sediments of individual rock types (andesite, rhyolite, granitoid, pumice, and scoria) were separated and crushed into powder using a steel anvil.
- A sequential leach was utilized to mimic relative rates of chemical weathering of the different MSH rock types.
- The sediments were sequentially leached for ~16 hours at room temperature with the following solutions: ultra-pure water (H_2O), 1 N acetic acid (CH_3COOH), and 1 N nitric acid (HNO_3).
- The leaches were analyzed using inductively coupled plasma optical emission spectroscopy (ICPOES).

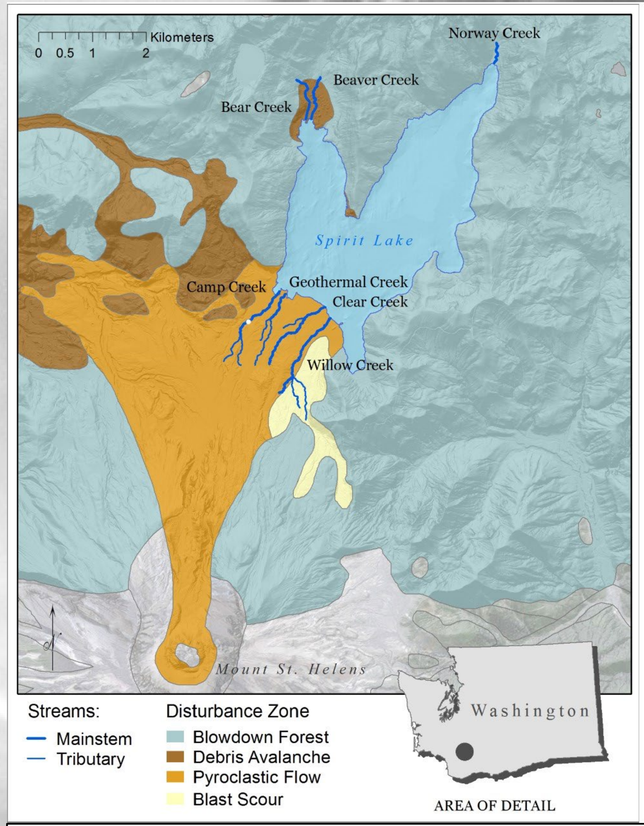
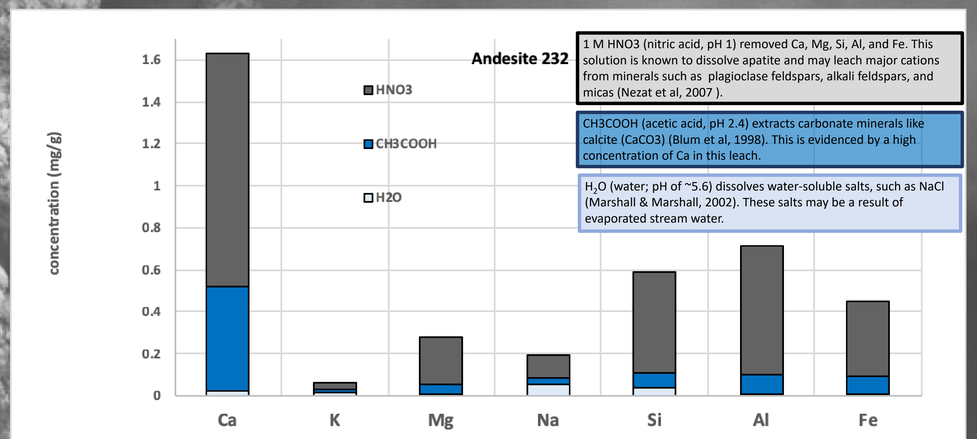


Figure 1 : This figure illustrates the key elements of the 1980 Mount St. Helens blast flow as well as some main creeks in the area. This image is from Blackman (2014).

Minerals	Elements							
	Ca	Mg	Na	K	Al	Si	Fe	Mn
Quartz - SiO_2						X		
Plagioclase - $NaAlSi_3O_8 – CaAl_2Si_2O_8$	X		X		X	X		
Biotite - $K(Mg,Fe)_3AlSi_3O_{10}(F,OH)_2$		X		x	X	X	X	X
Hornblende - $K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$		X		X	X	X	X	X
Magnetite - Fe_3O_4							X	
Apatite - $Ca_5(PO_4)_3$ (F,Cl,OH)	X							
Amphibole – $(Na, K)_{0-1}X_2Y_5(Si, Al)_8O_{22}(OH,F)_2$	(XY)	(XY)	(XY)	X	X	X	(XY)	(XY)
Ilmenite - $FeTiO_3$							X	
Pyroxene $(XY)(Si,Al)_2O_6$	(XY)	(XY)	(XY)		X	X		

Results



1 M HNO3 (nitric acid, pH 1) removed Ca, Mg, Si, Al, and Fe. This solution is known to dissolve apatite and may leach major cations from minerals such as plagioclase feldspars, alkali feldspars, and micas (Nezat et al, 2007).

CH3COOH (acetic acid, pH 2.4) extracts carbonate minerals like calcite (CaCO3) (Blum et al, 1998). This is evidenced by a high concentration of Ca in this leach.

H_2O (water; pH of ~5.6) dissolves water-soluble salts, such as NaCl (Marshall & Marshall, 2002). These salts may be a result of evaporated stream water.

Figure 2: Elemental composition of the sequential leachates of andesite, a common rock at Mount. St. Helens. Note, the sum of these three leachates does not represent the total composition of the rock. This is due to silicate minerals, such as plagioclase feldspars, potassium feldspars, pyroxenes, and biotite, being highly resistance to chemical weathering (Klein & Philpotts, 2017).

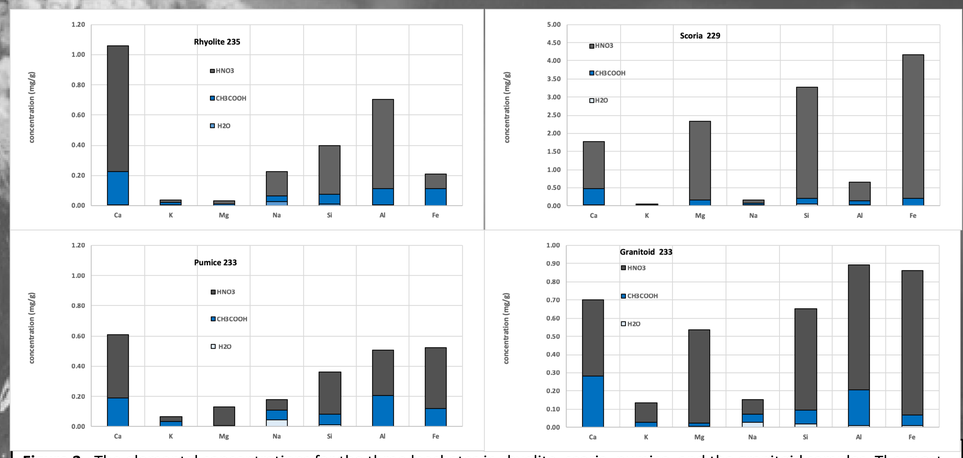
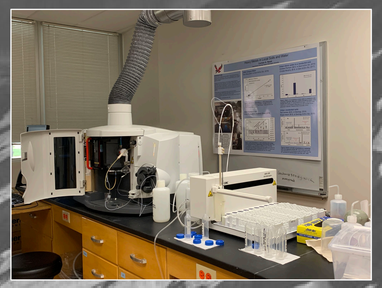


Figure 3 : The elemental concentrations for the three leachates in rhyolite, scoria, pumice, and the granitoid samples. The most concentrated elements leached in the rock types are Ca, Na, Si, Al, and Fe.



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Backround Image:
Krimmel, Robert, and USGS. "An Ash Plume Billows from the Crater atop Mount St. Helens Hours after Its Eruption Began on May 18th, 1980, in Washington State. The Column of Ash and Gas Reached 15 Miles into the Atmosphere, Depositing Ash across a Dozen States." The Atlantic , The Atlantic Monthly Group, 2015, www.theatlantic.com/photo/2015/05/the-eruption-of-mount-st-helens-in-1980/393557/#img01.

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Future Work

- Investigate the chemical composition of the rock and sediment leaches
- Compare leach data to stream water data.