Geochemical characterization of the Mount St. Helens "Spirit Lake" Stage

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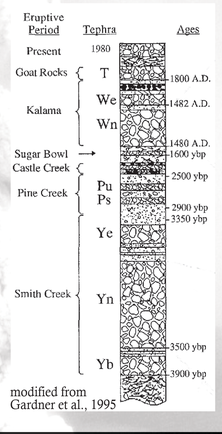
ABSTRACT SUMMARY

1. Mount St. Helens (MSH) has been the most active Cascade volcano over the Holocene.
2. Activity included several Plinian eruptions that produced significant amounts of rhyolitic tephra.
3. Recent research has recognized that **tephra sourced from western North America are being preserved in sequences on the east coast of the continent**.
4. The **lack of readily available glass geochemical data from proximal deposits** has stymied the identification of many "ultra" distal tephra characterized thus far.
5. Here we present the initial results of an ongoing project that is looking to **geochemically characterize all the major tephra producing events from the Spirit Lake phase** of MSH using proximal deposits mapped by Mullineaux (1996).
6. We present **glass major-element geochemistry** for **set D** (AD 1980), **layer T** (AD 1800) **set W** (ca. AD 1479-1482), and **set Y** (ca. 4000-3000 ^{14}C yr BP).
7. This data has allowed us to identify several distal tephra deposits to the level of layers within sets. We show that We, rather than Wn, is present on the east coast of Canada, and that layer T has a much greater distribution than would be inferred from its relatively small size.

Mount St. Helens over the Holocene

- During the Holocene, MSH experienced a long dormant phase for approximately 6000 years (ca. 10.4 to 4.0 ka).
- The last 4000 years have been defined by relatively continuous activity.
- This time defines the **Spirit Lake Stage**, when MSH produced more basaltic to dacitic material than it had been known for in the past.
- However, there were several larger events that produced significant amounts of rhyolitic tephra, some depositing visible beds as far as 500-900 km from source.
- These events are the focus of this study, and are highlighted in the summary table (right) and composite stratigraphic log (below).

The "whaleback" formed by activity in 2004. USGS



modified from Gardner et al., 1995

Eruptive stage	Eruptive period	Tephra units	Layers within sets	Approximate Age		Proximal Trajectory	Column Height	Volume
		Set D		1980 AD		ENE	19 km	0.3 km3
				1857 AD				
Spirit Lake	Goat Rocks	Layer T		1800 AD (dendro)		NE	16 km	0.4 km3
	Kalama	Set X	ash bed z	AD 1610 AD ± 40 years (^{14}C)		NE		
			Xh	1525 AD ± 25 years (dendrochronology)		E?		
			Xm			NE		
			Xs			NE		
			Xb			NE and E		
		Set W	Wd	~1500 AD		NE		
			ash bed					
			We		AD 1482 (dendro)	E	21 km	0.4 km3
			ash bed					
			Wb		AD 1480 (dendro)	NE		
			ash bed					
			Wa			NE		
			ash bed					
			Wn		AD 1479 (dendro)	NE	24 km	2 km3
	Sugar Bowl	Layer D		~1,200 ^{14}C BP	~AD 850-900	NE		
	Castle Creek	Set B	Bu - basaltic	~1,600-2,500 14C years ago	AD 270 (?)	E		
			Bi - dacitic		AD 190 (?)	E		
			ba 2					
			Bd - dacitic		BC 220 (?)			
			ba 1					
			Bo - andes		BC 250 (?)	ESE		
			Bh - andes		BC 280(?)	N and E		
	Pine Creek	Set P	v - flow?	~2,500 to 3,000 14C years ago	~ 2500 yr B.P.	E?		
			Py			E?		
			Pu			NE	15 km	0.2 km3
			Pa - flow?			E?		
			Ps			E or ENE	11 km	0.1 km3
			unnamed ash bed			NE?		
			Pm		BC 1180 (?)	E?		
	Smith Creek	Set Y	plp	~3,300 to 4,000 14C years ago		E		
			Yu (Y upper)			NE?		
			Yo			NE?		
			Yp - coignimbrite ?			NE		
			Yf			NE?		
			Ya flow and coignimbrite ash		~ BC 1680 (?)	E and NE		
			Yc (flow?) 2			E?		
			Ye		1770 BC ± 100 yrs	E or ESE	23 km	0.9 km3
			Yc (flow?) 1			E and NE		
			Yn		BC 1860(?)	NNE	31 km	4 km3
			Yd		BC 2100 ± 300 yrs	NE?		
			Yb		BC 2340 (?)	NNE	22 km	0.3 km3

The Last 200 Years

- Two major eruptions occurred.
- One during the Goat Rocks period, known as layer T (ca. AD 1800; Yamaguchi & Hoblitt 1995).
- The last major event was the historical eruption of 1980 (featured in the background for this poster)

Figure 1: Harker diagrams of layer T and the 1980 eruption. These two events are distinct from the other units investigated by their average SiO_2 wt%.

Figure 2: A comparison between proximal layer T, a distal layer T sample, and a cryptotephra layer reported by Mackay et al. (in prep) from Nova Scotia.

Figure 1

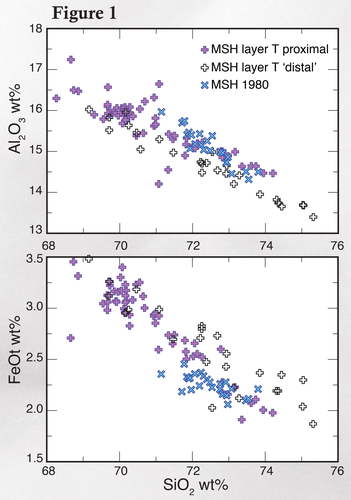
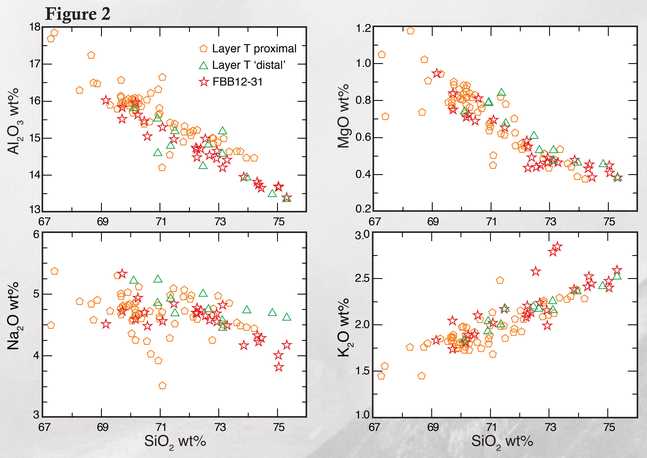


Figure 2



St. Helens set W

- Defined by two major events: Wn and We (AD 1479/1482; Yamaguchi & Hoblitt, 1995).
- Wn was the second largest event of the Spirit Lake Stage after Yn

Figure 1: Harker diagrams of set W show that all events are distinct, but most importantly, only major-element geochemistry is required to distinguish Wn from We.

Figure 2

Figure 2: Set W exposed at "stratigraphy viewpoint." (photo by S. Kuehn)

Figure 3: A cryptotephra layer reported by Mackay et al. (in prep) from NFLD clearly plots with We. This result mirrors the one suggested by Pyne O'Donnell et al. (2012).

Figure 1

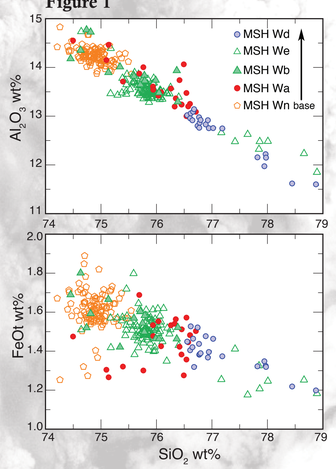
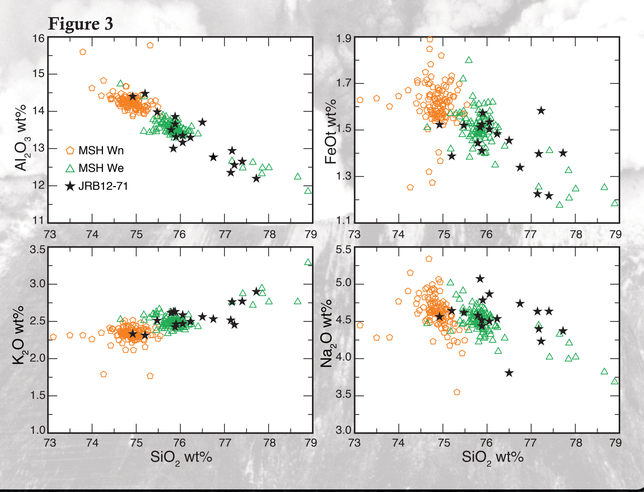


Figure 3



St. Helens set Y

- Are the oldest deposits of Spirit Lake, and represent the longest period (~700 yrs).
- Yn was the largest eruption of the Stage, Ye the third largest (after Wn).

Figure 1: Photo of the Muddy River quarry. Samples of sets W and Y for this study were collected from this site. (photo from online version of Mullineaux, 1996)

Figure 1

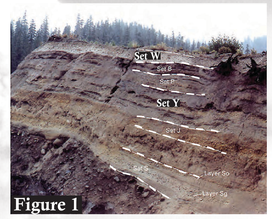


Figure 2: *Top:* Yn, Ye and Yb can be distinguished by glass major-element geochemistry. *Bottom:* Distal (visible) beds plotted with results confirm Yn is the predominant tephra to the north, although the result from Idaho indicates Yb has a broader distribution than thought.

Figure 2

References and Contact Information

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Gardner, J.E., et al., 1995. Petrologic diversity in Mount St. Helens dacites during the last 4,000 years: implications for magma mixing. Cont. to Min. Pet., 119: 224–238.
Pyne-O'Donnell, S.D.F., et al., 2012. High-precision ultra-distal Holocene tephrochronology in North America: Quat.Sci.Rev., 52: 6-11.
Mackay, H., et al., The foundations of a late Holocene tephrostratigraphic framework for eastern North America, in preparation.
Mullineaux, D.R., 1996. Pre-1980 tephra-fall deposits erupted from Mount St. Helens, Washington: U.S.G.S. Professional Paper, 1563, 99 p.
Yamaguchi and Hoblitt, 1995. Tree-ring dating of pre-1980 volcanic flowage deposits at Mount St. Helens, Washington. GSA Bulletin, 107, 1077–1093.
Westgate, J.A., 1977. Identification and significance of late Holocene tephra from Otter Creek, southern British Columbia, and localities in west-central Alberta. Can.J. Earth Sci., 14: 2593–2600.

USGS