Tephra 2014

Maximizing the potential of tephra for multidisciplinary science

3-7 August 2014 Portland, Oregon, USA

Field Trip to Mt. St. Helens

Monday, August 4, 2014

Including stops on the south and east sides:

Stratigraphy Viewpoint

Bear Meadow

Cascades Peaks

Windy Ridge *(omitted on day of trip)*

Guide prepared by Stephen C. Kuehn

Itinerary

7:30 A.M.	**Depart** for Mt. St. Helens from Portland State University at 1721 SW Broadway Ave. (adjacent to Cramer Hall and PSU Geology Department)
9:30-10:45 A.M.	**Stop 1**, Stratigraphy Viewpoint (near Ape Canyon trailhead) (Figure 1)
12:15-1:00 P.M.	**Lunch** at Bear Meadows
1:15-2:30 P.M.	**Stop 2**, Cascades peaks
2:45-4:00 P.M.	**Stop 3**, Windy Ridge viewpoint
7:30 P.M.	Arrive at Portland State University at 1721 SW Broadway Ave

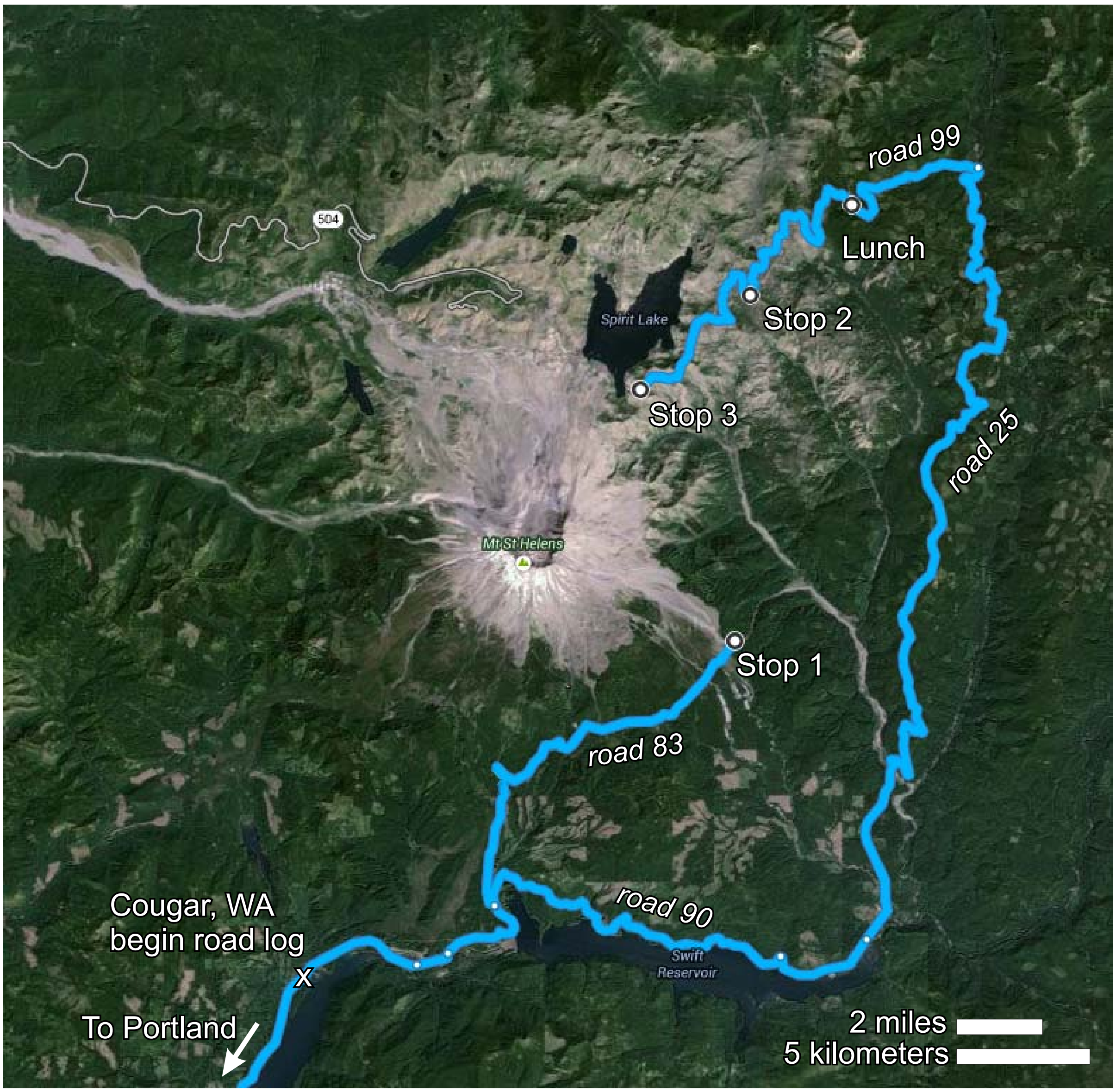

Figure 1 – Map of field trip route and stops.

Road Log and Directions

Note: distances are approximate

Description	Distance (miles)
Drive to Cougar, WA; Begin road log at intersection of Lewis River road with Old Lake Merrill road	0
Drive east on Lewis River road (becomes Forest Road 90)	6.6
Turn left onto Forest Road 83	3.0
Stay right to continue on Forest Road 83	8.1
Arrive at Stop 1, Stratigraphy Viewpoint – Walk to exposures on NE side of Muddy River upstream of bridge crossed by Road 83.	
Return to Forest Road 90 via Road 83.	11.1
Turn left onto Road 90.	11.9
Continue straight onto Forest Road 25. (Road 90 turns to right.)	25.0
Turn left onto Forest Road 99.	4.6
Arrive at Bear Meadows viewpoint - **Lunch**	
From the Bear Meadows parking area, turn left to continue west on Road 99.	5.9
Arrive at Stop 2, Cascades Peaks – Walk southeast on Forest Road 380 to the road cut just beyond where the road changes from paved to gravel.	
From the Cascade Peaks parking area, turn left to continue west on Road 99.	5.5
Arrive at Stop 3, Windy Ridge	
End of road log. To return to Cougar, turn left from the Windy Ridge parking area onto Road 99. Drive 16 miles back to Road 25. Turn right onto Road 25 and drive 43.5 miles continuing straight where Road 25 meets Road 90.	

Introduction

Numerous tephra deposits from Mt. St. Helens record a complex history and provide information about probable kinds, frequencies, and magnitudes of future eruptions. In addition they provide important time-stratigraphic markers across North America. The eruptive history of the broader Mt. St. Helens area spans at least the last ~300 ka (Clynne et al., 2008). This history has been organized into eruptive stages and periods. The tephra units are also organized into sets and identified layers within sets (Mullineaux, 1996; Table 1). Mt. St. Helens volcano is dominated by dacitic magmas, but overall the magma compositions range from olivine basalt to a substantial amount of andesite to the dominant dacite to rhyodacite. Rocks older than about 2.5 ka commonly contain phenocrysts of quartz, biotite, and cummingtonite, but these phases are generally absent in younger rocks.

Stop 1 – Stratigraphy Viewpoint

Stratigraphy viewpoint is located southeast of the summit of Mt. St. Helens along the Muddy River. It consists of two main exposures of tephras and interbedded lahars located upstream of the Road 83 bridge across the Muddy River (Figure 2).

Figure 2 – Area map for Stop 1.

Table 1 (following pages) – Summary of Mt. St. Helens tephra stratigraphy. The larger eruptions producing tephra-fall are highlighted in bold font. Compiled from Mullineaux (1996), Clynne et al. (2008), Pallister et al. (2003), Sarna-Wojcicki et al. (1983), Carey et al. (1995), and Yamaguchi (1983, 1985).

Eruptive stage	Eruptive period	Tephra units	Layers within sets	Approximate Age	Proximal Trajectory	Column Height	Volume	Description
Spirit Lake	Modern	1980 (Set D)		1980 AD	ENE	19 km	0.3 km3	Consists of blast, pyroclastic flow, and fall deposits erupted on May 18, 1980. Smaller tephra eruptions also occurred on 25-May, 12-June, 22-July, 7-August, and 16-18-October.
	Goat Rocks			1842 AD & 1857 AD				Small eruptions
		Layer T		1800 AD	NE	16 km	0.4 km3	The last voluminous tephra ejected by Mount St. Helens before 1980.
	Kalama	Set X	ash bed z	1610 AD ± 40 years (14C)	NE			Multiple andesitic beds recognized near the volcano. Contains some clasts of banded scoria indicating magma mingling.
			Xh	begins 1505 AD	E?			
			Xm		NE			
			Xs		NE			
			Xb		NE and E			
		Set W	Wd		NE			The initial event produced the large-volume, pumiceous layer Wn, the second largest Holocene tephra from Mount St. Helens. Layer Wn is overlain by several smaller pumiceous tephras, including the moderate-volume layer We. Contains scarce clasts of banded pumice indicating magma mingling.
			ash bed					
			We	1482 A.D. (dendro)	E	21 km	0.4 km3	
			ash bed					
			Wb	1480 A.D. (dendro)	NE			
			ash bed					
			Wa		NE			
			ash bed					
			Wn	late 1479 AD or early 1800	NE	24 km	2 km3	
	Dormant period of 600-700 years							
	Sugar Bowl	Layer D (fall & blast) and pyroclastic flows		~1,200 ^{14}C BP; ~850-900 AD	NE			Layer D is most recognized as a coarse dacitic layer. Often contains carbonized wood.

Eruptive stage	Eruptive period	Tephra units	Layers within sets	Approximate Age		Proximal Trajectory	Column Height	Volume	Description
Spirit Lake	Castle Creek	Set B	Bu - basaltic	~1,900-2,200 14C years ago	270 AD (?)	E			Includes andesitic, dacitic, and basaltic tephra.
			Bi - dacitic		190 AD (?)	E			
			ba 2						
			Bd - dacitic		220 BC (?)				
			ba 1						
			Bo - andes		250 BC (?)	ESE			
			Bh - andes		280 BC (?)	N and E			
	Pine Creek	Set P	v ash - flow?	~2,500 to 3,000 14C years ago		E?			Characterized by relatively few tephra fall layers but many pyroclastic flow deposits, including both lithic and pumiceous flows. Set P consequently includes only relatively small volume, fine-grained tephra fall layers. Layer v is characteristically pink.
			Py			E?			
			Pu		~ 2500 yr B.P. / 530 BC (?)	NE	15 km	0.2 km3	
			Pa ash-			E?			
			Ps			E or ENE	11 km	0.1 km3	
			unnamed ash			NE?			
			Pm		1180 BC (?)	E?			
	Smith Creek	Set Y	pbp ash	~3,300 to 4,000 14C years ago		E			Consists chiefly of two voluminous, coarse pumice layers interbedded with many smaller layers and pyroclastic flows. Yn, is the largest volume Holocene tephra known from Mount St. Helens. Ye is also a major tephra. Yb is a composite from multiple small eruptions. Yf, Yo, and Yu are lithic-rich. The pbp layer is a faintly-bedded and distinctively colored (pink-brown-pink) ash deposit. Set Y deposits typically contain cummingtonite.
			Yu (Y upper)			NE?			
			Yo			NE?			
			Yp - coignimbrite?			NE			
			Yf			NE?			
			Ya flow and coignimbrite ash		~1680 BC (?)	E and NE			
			Yc (flow?) 2			E?			
			Ye		1770 BC ± 100	E or ESE	23 km	0.9 km3	
			Yc (flow?) 1			E and NE			
			Yn		1860 BC (?)	NNE	31 km	4 km3	
			Yd		2100 BC ± 300	NE?			
			Yb		2340 BC (?)	NNE	22 km	0.3 km3	

Eruptive stage	Eruptive period	Tephra units	Layers within sets	Approximate Age	Proximal Trajectory	Column Height	Volume	Description
Dormant period between about 12.8 and 3.9 ka								
Swift Creek		Set J	Jg	poorly-dated; perhaps from about 13.8 to 12.8 ka	SW			Characterized by a few large-volume dacitic pumice layers that consist chiefly of lapilli near the volcano.
			Jb		SE			
			Jyn		NE			
			Jyo		SE			
			Js		E			
		ash-rich beds present between set S and set J						
		Set S	**So**	poorly-dated; probably about 16 ka	NE			Characterized by a few large-volume dacitic pumice layers that consist chiefly of lapilli near the volcano interbedded with multiple ash-rich layers.
			ash bed					
			Sg		ENE			
			ash bed					
			Ss		SE			
			ash bed					
			Sw		E			
			ash bed					
			Sb		E?			
Mostly dormant period between about 18 and 16 ka								
Cougar		White pumice pyroclastic flows.		~23.6–22.2 ka				
		Set K		~19,000 14C years ago	E and S?			Small-volume eruptions produced multiple thin beds of dacitic pumice and ash.
		ash-rich beds present between set M and set K						

Eruptive stage	Eruptive period	Tephra units	Layers within sets	Approximate Age	Proximal Trajectory	Column Height	Volume	Description
Cougar		Set M	Mt		E?			Characterized by several moderate-volume dacitic layers of pumiceous and lithic lapilli and ash, none of which is more than a few tens of centimeters thick near the volcano.
			ash bed					
			Mm		SE?			
			ash bed					
			Mp		E?			
			ash bed					
			Mc		SE			
			ash bed					
			Mo		SE?			
			ash bed					
			Mg		SE?			
			ash bed					
			Ms					
		Two-pumice pyroclastic flows.		~24 ka				
Mostly dormant period between about 35 and 28 ka years ago // ash-rich beds present between set C and set M								
Ape Canyon		Set C	Cs	continues to about 35 ka	SE?			Includes at least two large-volume dacitic pumice layers and other layers of smaller volume. The major layers consist chiefly of lapilli and small bombs near the volcano. Cy records one of the largest volume tephra eruptions from Mount St. Helens. Overall, the early record is relatively poorly-preserved and may be incomplete. Correlation of specific set C layers from one site to another is problematic.
			Cy		SE			
			ash beds					
			Cm		E or SE?			
			Cw		E or SE?			
			Ct		E or SE?			
			Cb	47,430±600 yr B.P. (14C)	S to SE?			
			older beds not preserved at the volcano	perhaps as old as about 300 ka				

The Stratigraphy viewpoint exposures were created by floods and lahars that swept down the Muddy River on May 18, 1980 causing widespread erosion. Portions of the exposures are described by Mullineaux (1996; sets B and J), Doukas (1990), and Crandell (1987). The northern exposure (Figure 3; Table 2) has multiple layers of tephra-fall, flows & surges, and lahars. Tephra sets S, J, Y, P, B, W, and possibly X are represented. The lowermost layer is a thick, reddish flow deposit which pre-dates tephra Sg. At the top are three lahars.

Figure 3 – Northern tephra exposure at Stratigraphy viewpoint. Photo taken in 2008.

Table 2 – Summary of sequence at Stratigraphy viewpoint northern exposure

Description of Layers
lithic rich lahar, 0-25 cm (TOP)
lithic rich lahar, 20-30 cm thick, abundant organic matter at top (wood, bark)
lithic rich lahar, 50 to 95+ cm thick, fine ash and concentration of roots at top
gray to white ash, 2 cm thick
ash and small lapilli, lithic rich with some pumice, poorly sorted, 11 to 15 cm thick
white to tan fine ash, 0.5 cm thick
black ash or sand with few white pumice lapilli (reworked?), 1-2 cm thick; **set X ?**
rounded pumice lapilli in ash, poorly sorted, pyroclastic flow or lahar, 10-15 cm thick
white to gray fine ash, 0.5-1 cm thick
heterogeneous mixture of lithic fragments in finer matrix, probable lahar, 40-50 cm thick
fine ash, pale gray to pink, 2 cm thick
darker gray coarse ash, 1 cm thick
coarse, loose, white tephra-fall with pumice exceeding 10 cm in largest diameter, 16-22 cm thick; **We**
sandy gray ash and lapilli, 2-3 cm thick
white to pale gray pumice lapilli, 3-4 cm thick; **probably Wn**
coarse lithics and white pumice in sandy matrix, about 1.3 m thick, probable lahar
gray to white ash, thinly bedded, probably cross-bedded, 2-4 cm thick
compact, wood-rich organic bed, 0.5 to 4 cm thick
gray fine ash, semi-continuous, 0.5-1 cm thick
ash and scoria, variable color - orange to gray to brown to black, 12-16 cm thick

scoria lapilli with sparse ash at top, lapilli in abundant ash at bottom; Orange to brown, many burrows, 10-12 cm thick total; **Bu**
coarse white ash and lapilli, normally graded, 2-4 cm thick; **Bi**
gray ash (4-10 cm) over black ash (2-10 cm),12-20 cm total thickness, **ba**
scoria lapilli (4 cm) over scoria & ash (2 cm) over scoria with sparse ash (2 cm), **part of Bo**
thick, poorly-sorted bed of variable thickness containing ash, scoria lapilli, and bombs, faintly bedded, about 55 cm thick at nose of ridge; **set B pyroclastic flow or surge**
scoria lapilli (2 cm) over scoria in ash matric (2 cm) over scoria (6-7 cm); **bottom of set B**
fine pink ash, 5 cm thick, abundant charcoal and partially charred wood at top; **ash bed v**
fine pink ash with few lapilli (3 cm) over fine pink ash (4 cm) over pinkish-gray ash with abundant lapilli (3 cm) over ash with few lapilli (3 cm); **may be Py**
coarse ash with small lapilli, lithic rich, sparse fine ash coating, 4-8 cm thick; **may be Pu**
bedded fine and coarse ash, pinkish to dark gray at base, gray coarse ash of variable thickness in middle, 5-12 cm total, **may be part of Pa**
pumiceous coarse ash with lapilli to at least 5 cm, thinnly bedded to massive, some cross-bedding in upper part, variable thickness of 10-30 cm, **may be part of Pa**
tan to gray ash, 2-8 cm thick, gray upper part is cross-bedded, **may be part of Pa**
pink ash with scarce lapilli, ~2 cm, orange coloration and charcoal at top, **may be part of Ps**
gray ash & scarce lapilli (~3 cm) over coarse ash with lapilli (~4 cm); **may be part of Ps**
gray ash (0.5-1 cm) over lapilli and coarse ash (2 cm); **may be part of Ps**
tan to pink ash (1-2 cm) over lapilli and coarse ash (1-2 cm); **may be Pm**
pink ash, 4-12 cm thick, top 2-3 mm orange-brown with sparse charcoal; **probably pdb**
pink to orange ash with few lapilli, 12-25 cm thick, some bedding locally preserved in lower part, abundant charcoal and charred wood at top
lapilli and coarse ash, coarsest at base, 4 cm thick
gray ash, 2 cm
lapilli up to 5 cm in coarse ash, typically 2 cm thick
gray to pink ash, 2 cm
lapilli up to 5 cm in coarse ash (3-6 cm thick) over coarse ash (2 cm thick)
pinkish gray to tan fine ash (4 cm) over white, pumiceous coarse ash (0-2 cm)
lapilli and ash (~12 cm) over coarse lapilli (~13 cm), **probably Ye**
cross-bedded ash and lapilli, color grades from yellow top to gray base, contains near-horizontal twigs, <u>abundant</u> conifer needles in bottom 15 cm, 70-80 cm thick, probably surge deposits
tan to gray fine ash, faintly bedded, 7 cm thick
fine and coarse ash, slightly darker than above, 14 cm thick
orange to brown lapilli in ash, some charcoal, 15 cm thick, wavy and gradational base
coarse lapilli fall, orange to orange-brown, about 56 cm thick, **Jb**
orange lapilli In matrix of gray ash, 9 cm thick; **Jyn**
coarse lapilli fall, coarser and paler color than Jb above, 29-35 cm thick; **Jyo**
mostly fine ash, 7-8 cm thick; **Js**
pale tan and poorly-sorted layer, possibly a pumiceous lahar, about 85 cm thick
angular gray lithic clasts (dacite) in ash, about 135 cm thick
cross-bedded, tan to gray ash and lapilli, 16-22 cm thick, reddish oxidation in top 1 cm
tan to reddish gray fine ash (2 cm) over pinkish gray lapilli in ash (10 cm)
lapilli and coarse ash, 5 cm thick; **probably So**
yellow to white lapilli with gray to tan fine ash in upper part, about 17 cm thick; **probably Sg**
gray sandy ash (0-1 cm thick) over tan fine ash (1 cm thick)
thick red to gray coarse ash and lapilli, more than 1.1 m thick (BOTTOM)

Lunch – Bear Meadows

Bear Meadows viewpoint is near the location where Keith Ronnholm and Gary Rosenquist took a series of photographs of Mt. St. Helens on the morning of May 18. These include Rosenquist's famous photographs (Figure 4) of the initiation of the landslide and the early phases of the eruption. Bear Meadows is about 11 miles from the volcano and a little more than 1 mile (2 km) from the edge of the blast zone.

Figure 4 – Two of Gary Rosenquist's photos.

Stop 2 – Cascades Peaks

Stop 2 is located in a large road cut along road 380 just beyond the edge of the pavement (Figure 5). This road cut contains several tephra beds including 1980, layer T, set X, Wn, set B, set P, Yn, and set J. Similar nearby sequences are described by Doukas (1990; at Independence Pass trailhead) and Carey et al (1995; site 24).

Figure 5 – Area map for Stop 2.

Stop 3 – Windy Ridge

Windy Ridge provides sweeping views of to the west from the crater of Mt. St. Helens to Spirit Lake. The best views are a short hike to the top of the hill just north of the parking area. The 1980 blast deposit is about 3 ft (1 m) thick in this area and is covered by thin 1980 fall deposits. The forest was almost completely removed by the blast with only a few splintered remains left behind. The modern Spirit Lake (Figure 6) was created by the debris avalanche which filled much of a former valley. Hummocky topography in the distance to the west is part of avalanche deposit and contains fragments the size of large houses. Portions of the 1980-1986 and 2004-2008 lava domes are visible within the crater.

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