Cascade Range Lahars (Volcanic Debris Flows)

JB Maynard 2010

The most devastating product of a volcanic eruption is a *lahar*, from an Indonesian word for mudflow. During an eruption much of the snow and ice on the volcano peak may melt to produce a sediment-laden slurry that moves rapidly downhill, sweeping away everything in its path or, at the distal end, burying everything in suffocating mud. Non-eruptive lahars also occur, initiated by landslides or by rain events. The rock mass making up a volcano is surprisingly weak because of cooling-induced fractures and because of hydrothermal alteration, so collapse of a large segment of the volcano, with no warning from rising magma, can occur and generate damaging lahars.

Introduction – lahar definitions and processes

The terminology applied to the various types of granular flow deposits associated with volcanoes is wildly variable among various authors. For consistency, we will adopt a scheme presented by Scott et al. (2001). They differentiated two main categories:

- **Debris avalanches** – dominantly grain flows, controlled by interparticle friction and collisions. Has abundant "megaclasts" > 1 meter. Often these are made up of fragile or altered lithologies. Has a trimodal size distribution: megaclasts >1 m; clasts 2 mm to 1m; matrix < 2 mm.

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- **Debris flows** – mass flows controlled by excess pore pressure in a viscous pore liquid. Bimodal size distribution: clasts and matrix. A **lahar** is a volcano-associated debris flow. Some clasts may be fragile lithologies or have "jig-saw puzzle" texture.

	
Megaclasts eroded from the Osceola Mudflow, White River, Mt Rainier	Jigsaw puzzle clast in S Fork Toutle drainage, Mt St Helens

Debris avalanches and debris flows have a wide zone of overlap as shown below (Figure 15 of Scott et al., 2001)

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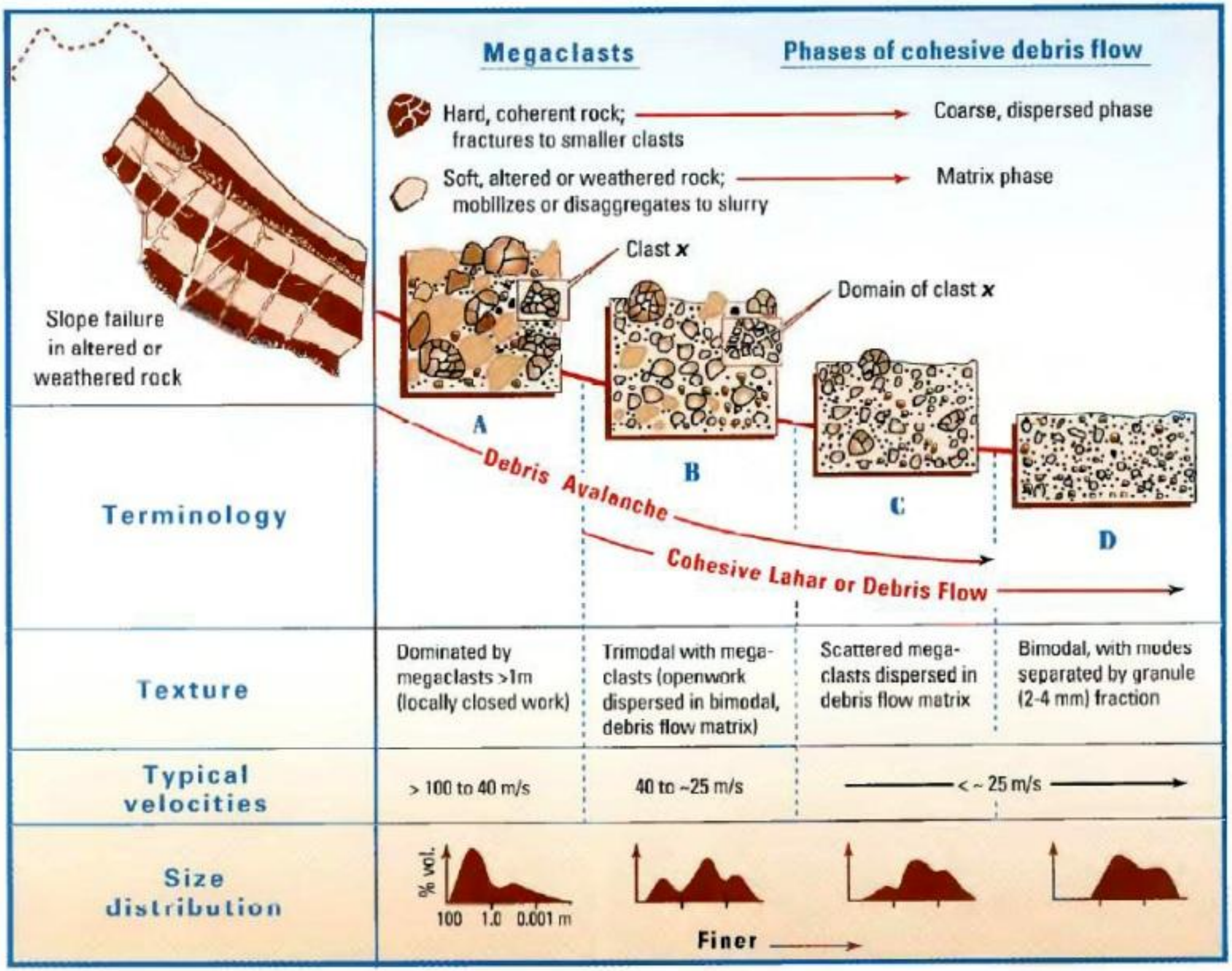

Debris flows may be either “non-cohesive” or “cohesive”:

- **Non-cohesive debris flows** – dominated by sand-sized particles in the matrix. Tend to originate as meltwater surges or lake breakouts (fines have been previously washed out). Generally associated with eruptions.
- **Cohesive debris flows** (aka mudflows) – have a significant proportion (> 5 %) of silt and clay in the matrix. Tend to originate as landslides formed during flank collapse in hydrothermally-altered material or in sector collapse of the main peak. May also be eruptive, but often occur independent of eruptive activity.

The term “mudflow” is now discouraged, although retained in formal stratigraphic names, because the actual amount of mud can be quite small. Also note that some earlier authors use the term *lahar* for cohesive debris flows, confining the term *debris flow* to the non-cohesive variety.

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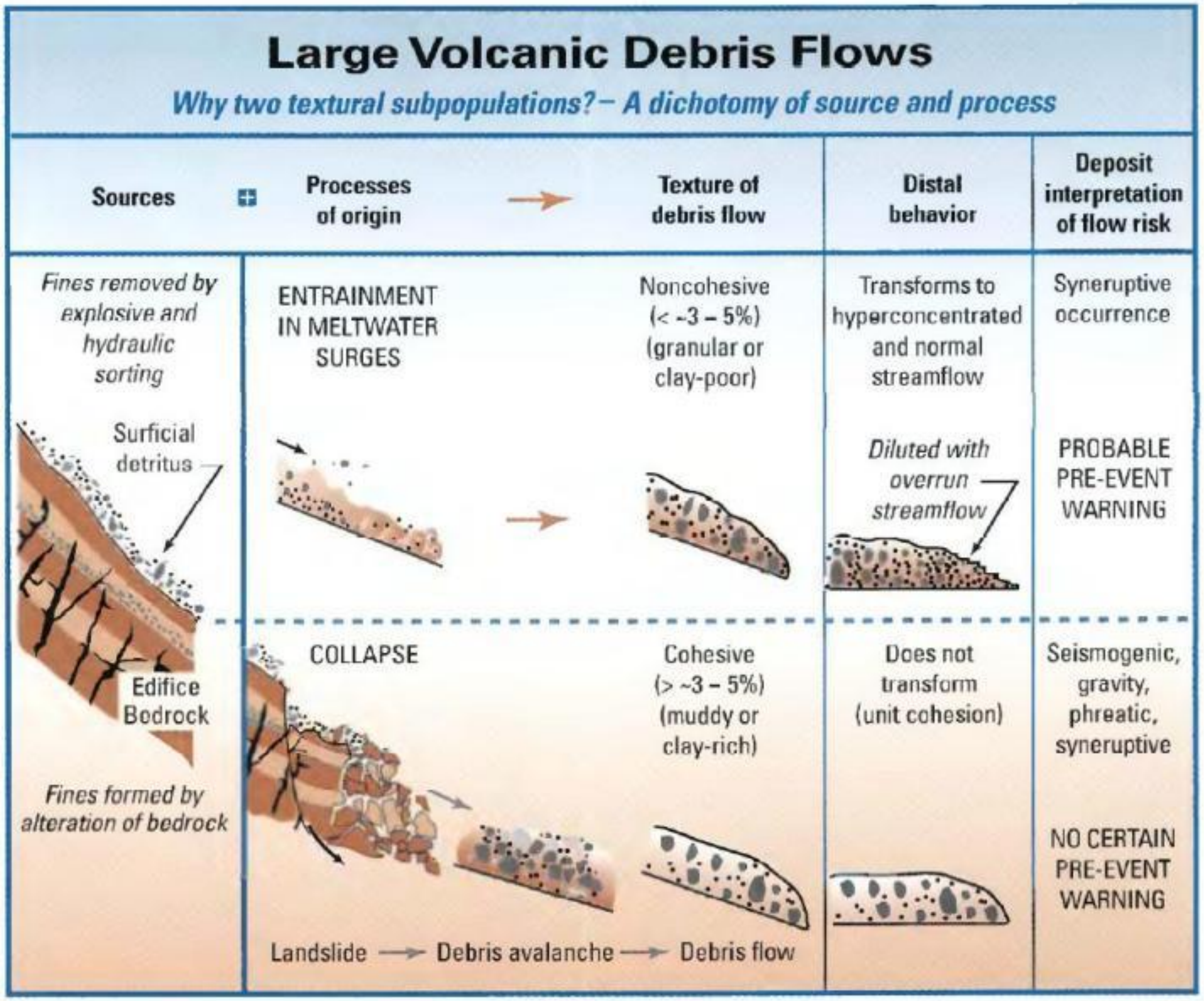

(Figure 1 of Scott et al., 2001).

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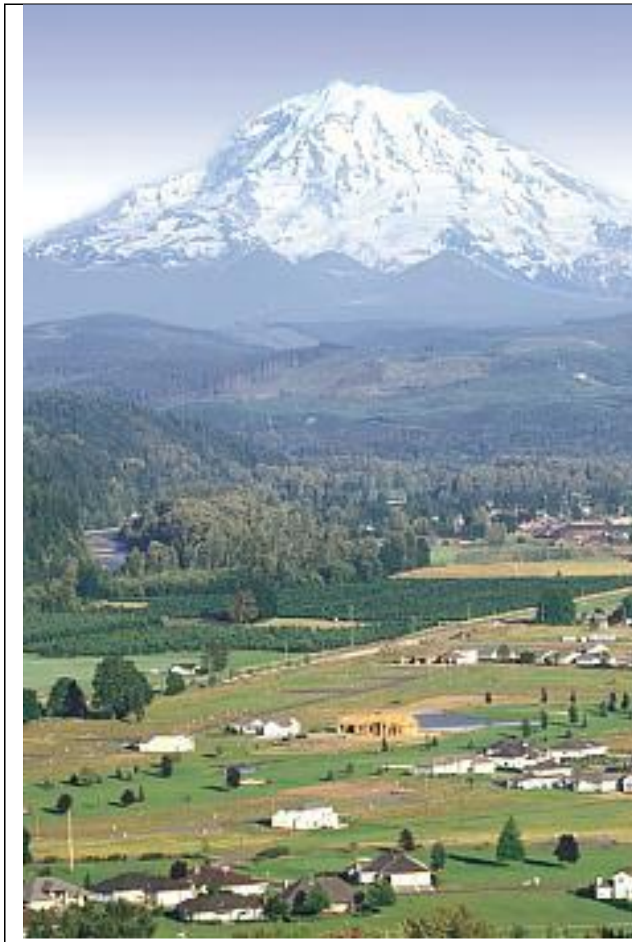
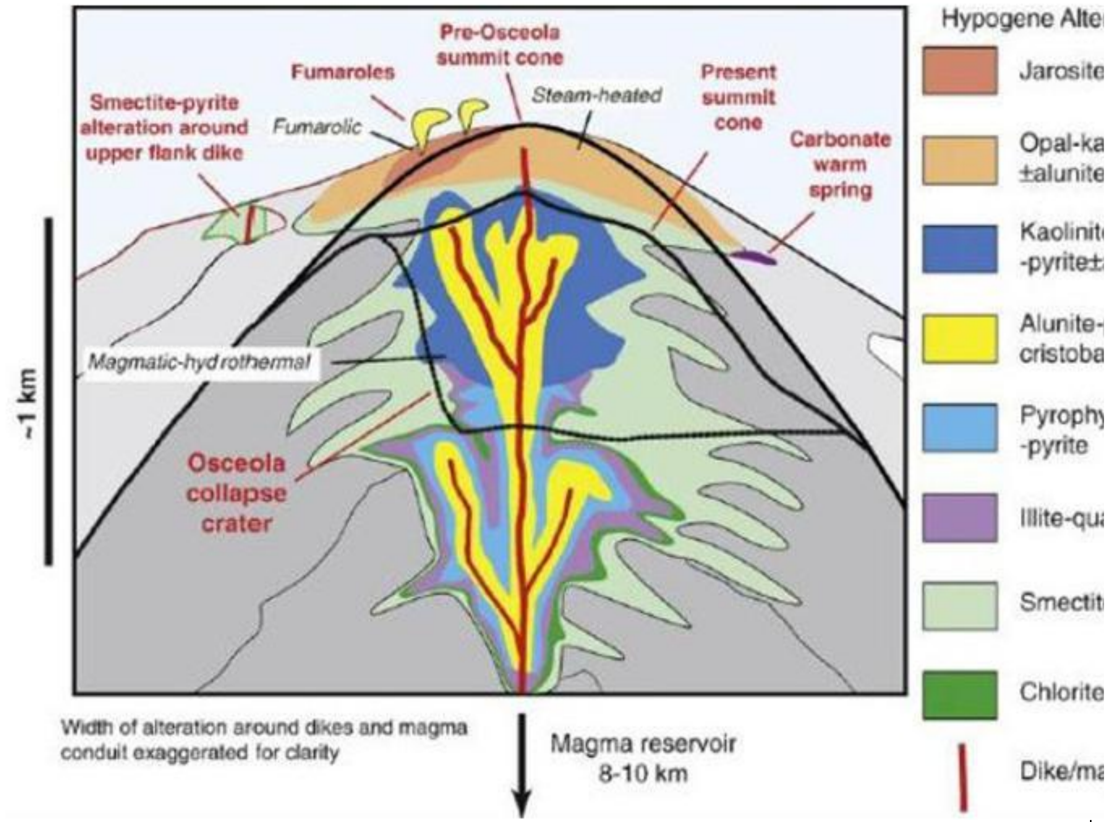
Part 1: Lahars on Mt. Rainier

Mt Rainier periodically produces lahars that flow all the way to the sea. Key factors are its very steep profile and highly altered rocks.

http://www.sedimentaryores.net/Cascades/MtStHelens/Cascade%20Range%20Lahars.pdf

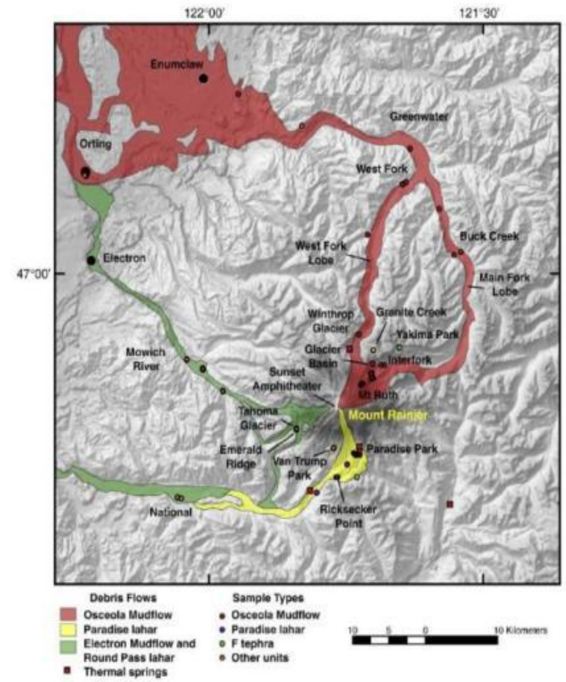




John et al., 2008, fig. 11B

Examples of lahars from Mt. Rainier (modified from Table 3 of Scott et al., 2001)				
Name	**River Valley**	**Age**	**Run-out distance-km**	**Volume-km^3**
Tahoma	Nisqually	400	>18	0.10
Electron	Puyallup	500	68 (Puget Sound)	0.23
“1000-yr-old” lahar	Puyallup	1000	>24	0.20
Round Pass mudflow	Puyallup	2600	>31	0.40
Round Pass mudflow	Nisqually	2600	>25	0.17
Unnamed lahar		2900	>14	0.15
“Pre-Y” lahar	Puyallup	3490	>36	0.15
Osceola mudflow	White	4832	125 (Puget Sound)	3.8

White River valley with Osceola Mudflow showing great height of the original flow



Distribution of Osceola Mudflow deposits (John et al., 2008, fig. 5)

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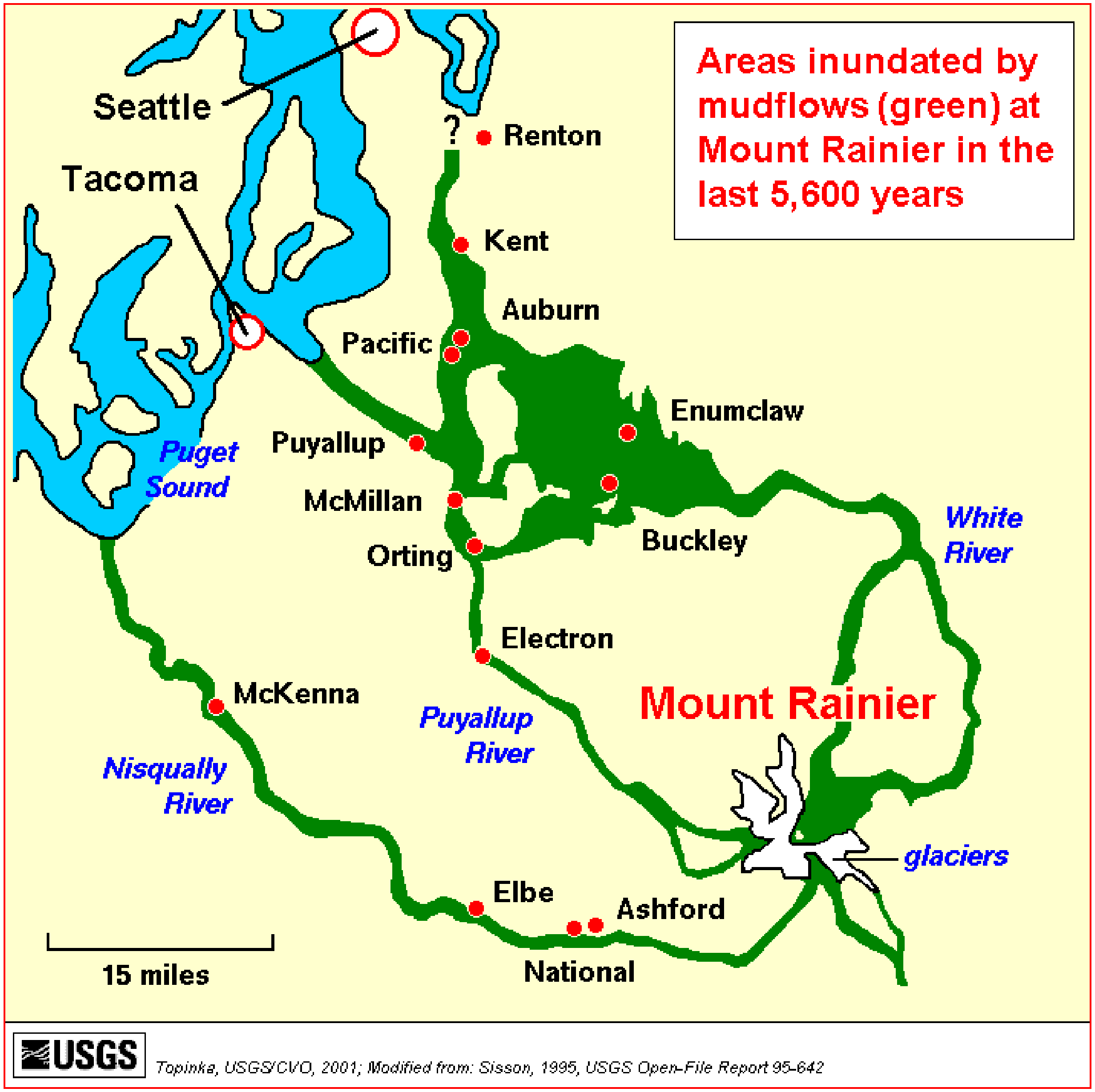

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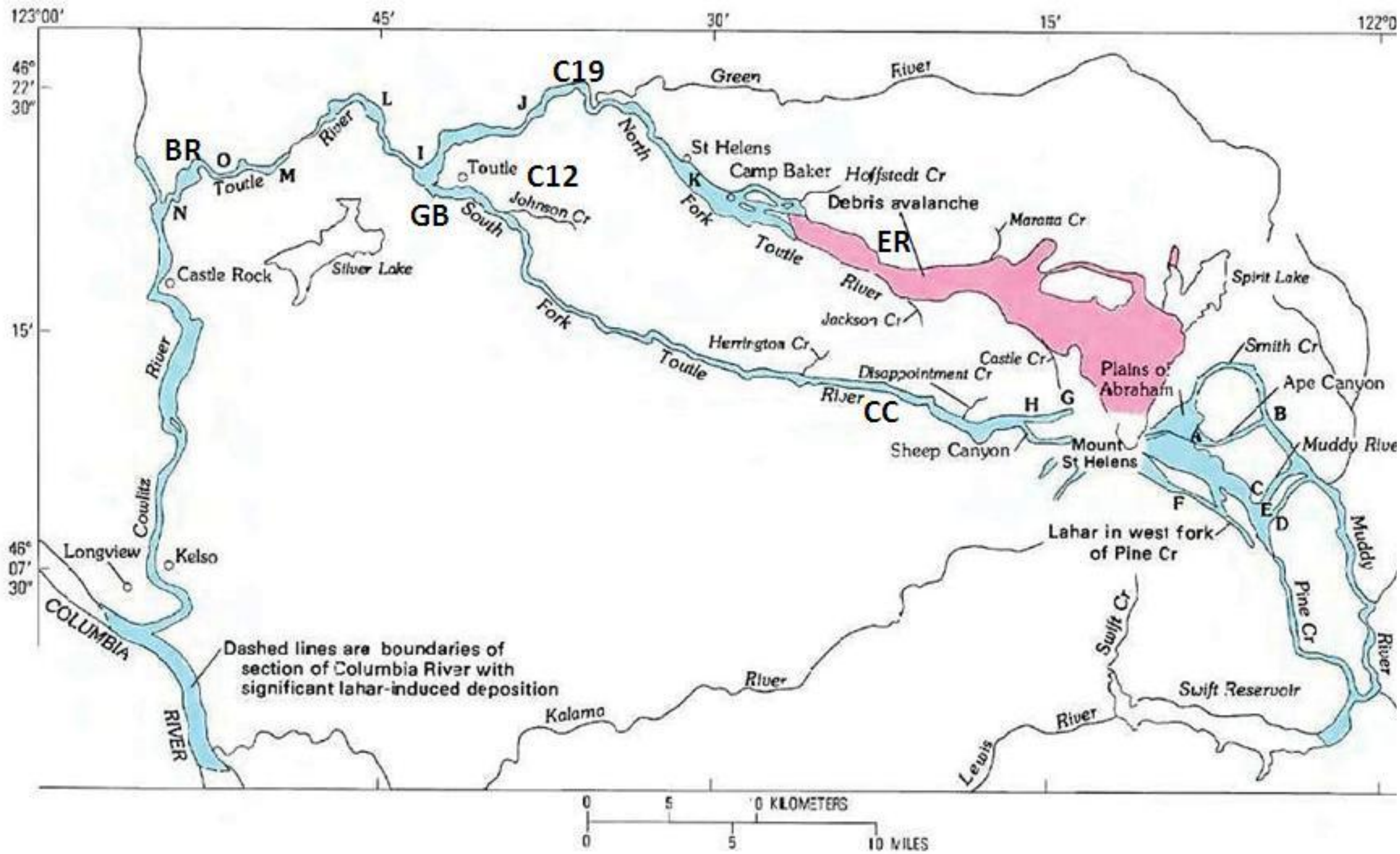
Part 2: Lahars on Mt. St Helens

Much of what we know about lahars is based on detailed observations of the events of May 18, 1980 on Mt St Helens and measurements on the resulting deposits.

The action that day was opened at 0832 by a giant sector-collapse landslide that removed the north face of the mountain. The pressure release on the magma chamber opened the way for an overpowering lateral blast that destroyed everything on the north side of the volcano. The landslide also produced a large debris avalanche that filled the North Fork of the Toutle River. At the same time, debris flows were intiated in other drainages, stimulated by the melting of 70 % of the glacial ice on the mountain. Late in the afternoon, the debris avalanche deposit had aquired sufficient water to generate a giant debris flow that swept down the Toutle River valley beyond the I-5 bridge and into the Cowlitz River and then into the Columbia – a distance of over 120 km. When it reached the Columbia, it deposited 45 million cubic meters of sand and gravel, raising the channel depth from 12 m to 3.5 m. The channel was blocked to ocean-going vessels for 13 days.

http://www.sedimentaryores.net/Cascades/MtStHelens/Cascade%20Range%20Lahars.pdf



The Lahars of May 18, 1980, from Janda et al., 1981. Letters refer to areas described in the table below

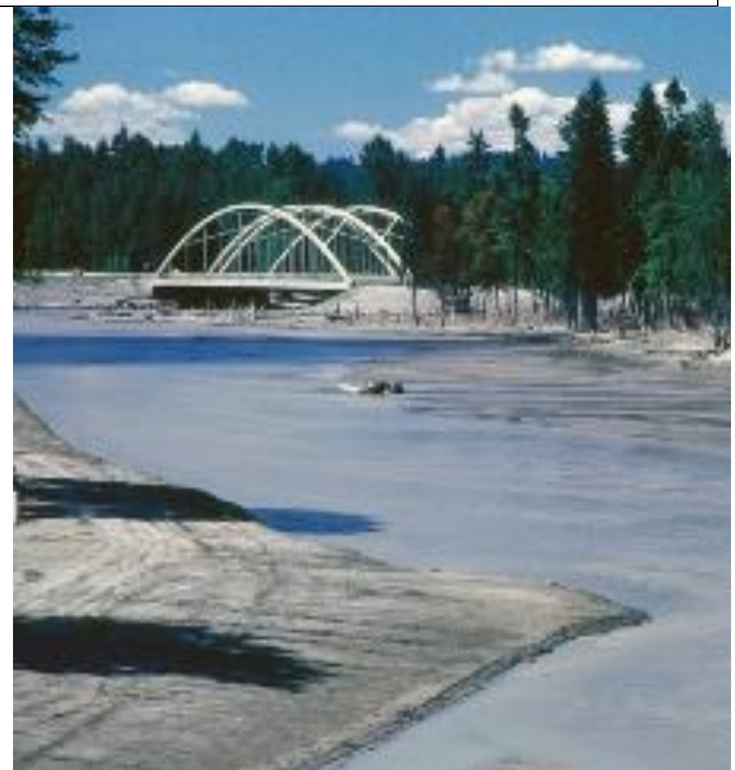
Lahars of May 18, 1980 on Mt St Helens *(data taken from Janda et al., 1981 and from Cummans, 1981)*								
Drainage	Map Symbol	Km above mouth of Cowlitz R	Time of arrival	Time of peak flow	Height	Speed m/sec	Deposit thickness	
Southwest drainages								
Upper Muddy River	A		0832		10-20 m	32	2 m	
Smith Creek	B					40		
Muddy River	C					20		
Hoo Hoo Lake	D							
W Fork Pine Creek	E							
E Fork Pine Creek	F				10 m	31	0.5-2.5 m	cohesive
South Fork Toutle River								
S Fork Toutle R	G		~0835				1-2 m	
S Fork Toutle R	H		~0835		15 m	*12.2*	1-2 m	

S Fork Toutle R – 1st flow	CC	103		0850				
S Fork Toutle R – 2nd flow	CC	103	1400					
Weyerhauser Camp 12	C12	68	1003	1010		*10.5*		
Gardner Bridge over S Fork – 1st flow	GB		1013		2-3 m	3-4	5 m	Lithic-rich
Gardner Bridge over S Fork – 2nd flow	GB							Pumice-rich
Toutle River, Main Stem – flow from S Fork								
Confluence – 1st flow from S Fork	I – Coal Bank Bridge	59	1020	1050	4 m	*5.5*	~1 m	Non-cohesive
Toutle River	L					6-8		Cohesive
Toutle River	M – Tower Bridge	43		1150		*6.7*	7 m	Cohesive
Toutle	O					1.5		
Toutle River	N – Old Pacific		1300				4 m	

	Hwy (WA99) bridge							
Cowlitz R @ Castle Rock		28	1310	1330		3.6		
Cowlitz R @ Longview		8	1615	1700		2.3		
North Fork Toutle River								
Elk Rock	ER	101	1325	1330		3.5		
Camp Baker		88	1357	1500		3.1		
N Fork Toutle R	K					4-5	0.5-2 m	
Green River			1530					
Camp 19	C19	73		1700		*3.5*		
N Fork Toutle R	J					12	~2.5 m	
Boys Ranch	BR	65	1745	1800		*2.5*		
Toutle River, Main Stem – flow from N Fork								
Confluence – flow from N Fork	I – Coal Bank Bridge	59	1810	1900	16 m	*5.5*	5-7 m	Cohesive
Toutle River	L					6-8		Cohesive
Toutle River	M – Tower	43	2029	2115		*6.7*	7 m	Cohesive

	Bridge							
Toutle	O					*1.5*		
Toutle River	N – Old Pacific Hwy (WA99) bridge		2030	2200			4 m	
Cowlitz R @ Castle Rock		28	2030	2400		*2.2*		
Cowlitz R @ Longview		8		0400 May 19		*2.0*		
Flow rates in italics are average values for the reach above the indicated position; others are estimates of instantaneous rates								

http://www.sedimentaryores.net/Cascades/MtStHelens/Cascade%20Range%20Lahars.pdf

Examples of lahars from Mt St Helens associated with the 1980 eruption			
Location	**Example**	**Location**	**Example**
At I-5 bridge over Toutle River, summer 1980		I-5 bridge over Toutle River, summer 1980	

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At bridge over S Fork of Toutle River, summer 2009	 http://www.sedimentaryores.net/Cascades/MtStHelens/South_Fork.html	At bridge over S Fork of Toutle River, summer 2009	
Coal bank bridge over WA 504 covered by lahar from N Fork, May 1980		Lahar from N Fork deposited at Tower Road bridge (map location M)	

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Part 3: Lahars on Mt. Hood

Compared to Rainier and St Helens, Mt Hood has a lower level of lahar activity, but damaging events do occur.

According to Scott et al., 1997, about 1,500 years ago, a moderate-size debris avalanche originating on the upper southwest flank of Mount Hood produced a lahar that flowed down the Zigzag and Sandy River valleys. It swept over the entire valley floor in the Zigzag-Wemme-Wildwood area, and inundated a broad area near Troutdale, where the Sandy flows into the Columbia River—a total distance of about 90 kilometers (55 miles). More than 100,000 years ago, a much larger debris avalanche and related lahar (see photos from the area along the railroad) flowed down the Hood River, crossed the Columbia River, and flowed several kilometers up the White Salmon River on the Washington side. Its deposit must have dammed the Columbia River at least briefly.

A damaging lahar occurred in December 1980 when intense warm rain (with rapid snowmelt) triggered a flow in Polallie Creek that killed a camper at the creek mouth and temporarily dammed the East Fork Hood River. The ensuing dambreak flood destroyed about 10 kilometers (6 miles) of Oregon Highway 35 and other downstream facilities and caused about $13 million in damage (Galino and Pierson, 1985).

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Mt Hood lahars			
Location	**Example**	**Location**	**Example**
Polallie Creek at OR 35		Polallie Creek at OR 35	

http://www.sedimentaryores.net/Cascades/MtStHelens/Cascade%20Range%20Lahars.pdf

Along Oregon 35		Mt Hood railroad at OR 35	
Mt Hood railroad at OR 35		Mt Hood railroad at OR 35	

Mt Hood railroad at OR 35		Debris flow in White River drainage	

Selected References for Mt Hood

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