Volcanic Hazards Overview

<u>**Lecture Objectives**</u>

-Main types of hazards (presented here: lahars, plumes, calderas, directed blasts, pyroclastic flows)

-Eruption processes

-General monitoring strategies

Alwyn Scarth: Vulcan's Fury (1999)

- volcanic hazards and human impacts.
- translated original eyewitness documents; cleared up a lot of misinformation and brought out a lot of new information.

Overall: volcanic hazards are semi-predictable, but they differ from other hazards in that the length, type, and magnitude of the activity can vary widely.

Read **Vesuvius** chapter!

Keys for reading:

- how effective were the various groups (science, public, government) at hazard mitigation?
- key hazards
- key mitigation problems
- realistic solutions

Magma types - > explosive and hazard potential (generally!)

-Which parameters can be monitored easily?

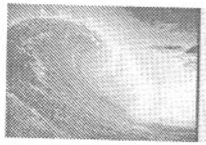


TABLE 7.5 COMPARISON OF THREE TYPES OF MAGMA

	VOLCANIC ROCK TYPES		
	BASALT	ANDESITE	RHYOLITE
Rock Description	Black to dark gray; contains Ca-plagioclase, pyroxene, olivine	Medium to dark gray; contains amphibole, pyroxene, intermediate Ca-Na-plagioclase	Light-colored; contains quartz, K-feldspar, biotite, Na-plagioclase
Volume at Earth's Surface	80%	10%	10%
SiO_2 Content	45–55%	55–65%	65–75%
	increasing SiO_2 →		
Temperature of Magma	1,000–1,300°C	800–1,000°C	600–900°C
	decreasing temperature →		
Viscosity	Low (melted ice cream)		High (toothpaste)
	increasing viscosity →		
Water Dissolved in Magma	~0.1–1 wt. %	~2–3 wt. %	~4–6 wt. %
	increasing water →		
Gas Escape from Magma	Easy		Difficult
	increasing difficulty →		
Eruptive Style	Peaceful		Explosive
	increasing explosiveness →		

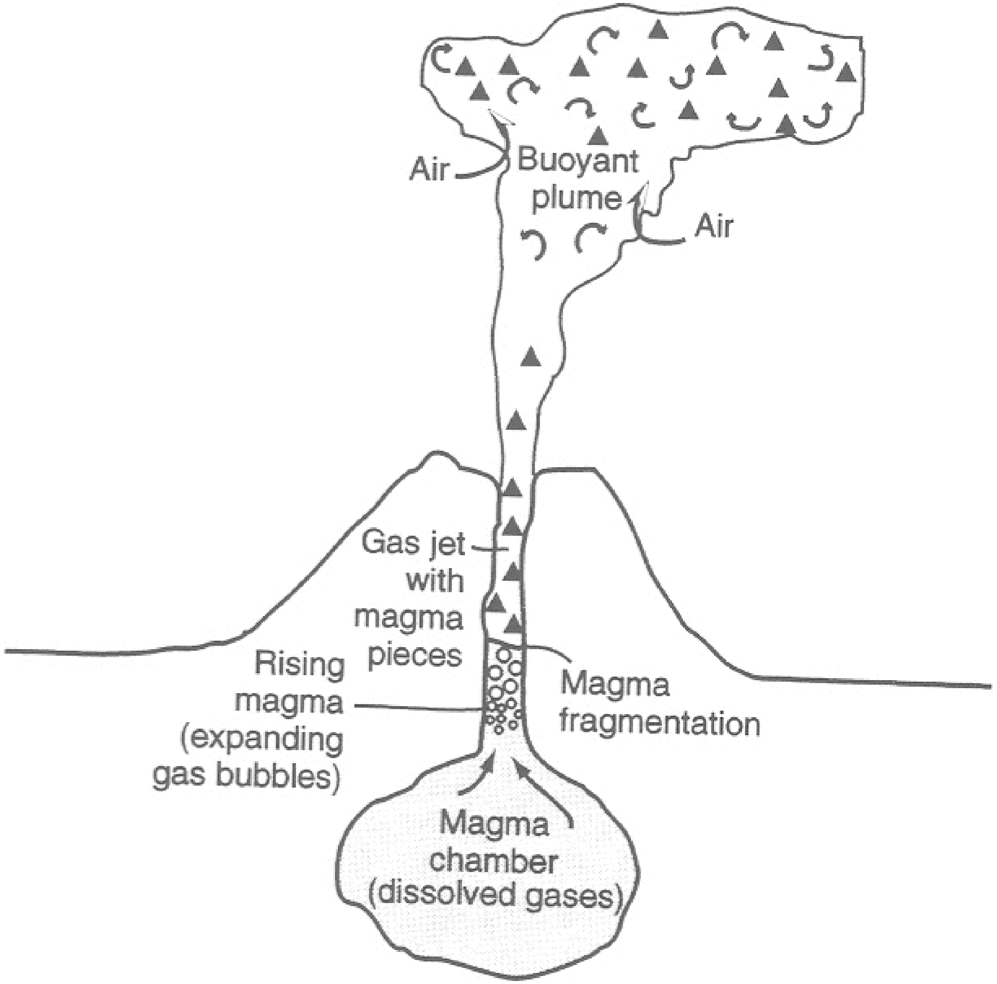


FIGURE 7.10

Anatomy of an eruption. As magma rises to levels of lower pressure, gas comes out of solution, forming bubbles that overwhelm magma and create a gas jet leading to a buoyant plume.

Most of the plume rise is through buoyant processes, rather than a gas thrust.

-How high will a plume rise?

-Where does most fragmentation occur?

-Where do most gas bubbles occur?

-What does a magma chamber and conduit really look like?

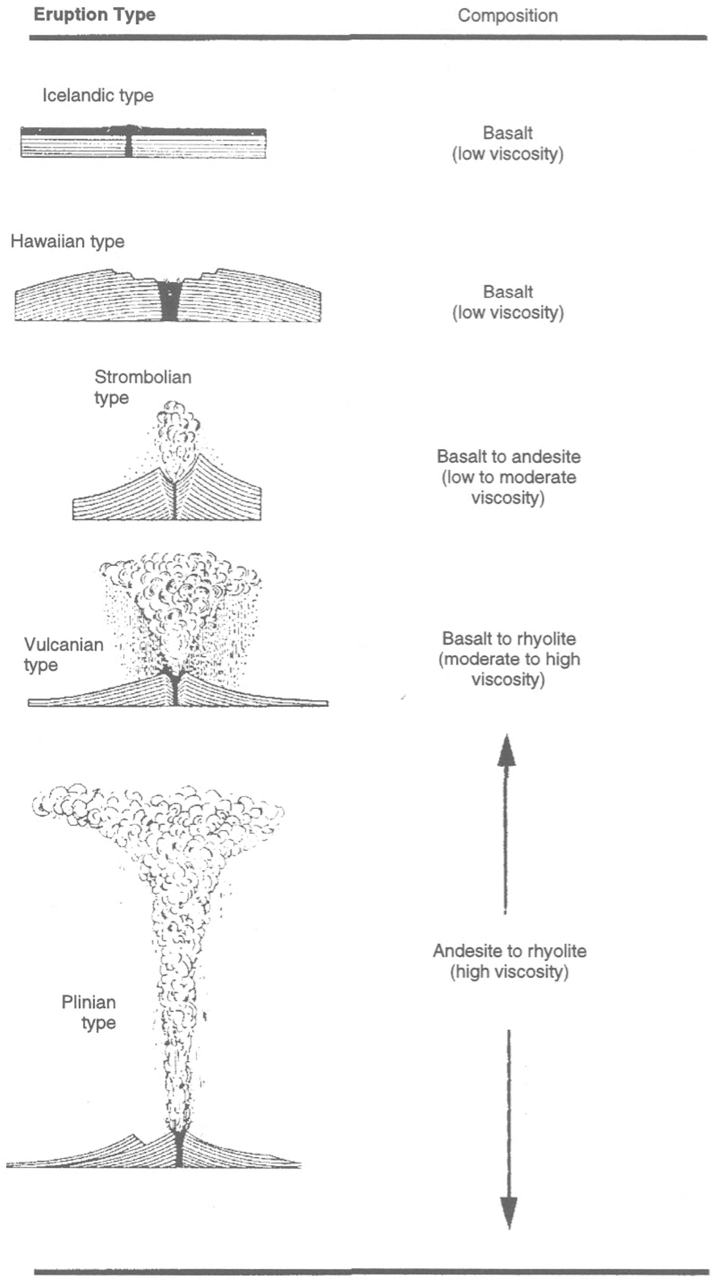


FIGURE 7.18
Some types of volcanic eruptions.

-Which naming convention doesn't fit with the others?

-what is viscosity, and how does it affect eruption style? Volcano structure?

-can eruption physics/chemistry change over time? How?

Volcanic Explosivity Index: Chris Newhall and Steve Self (1982)

-mainly a function of erupted material and plume height. How well are these known? Preserved?

-why develop an eruption index?

occurred in 1991 when Mt. Pinatubo erupted.

Table 7.9 Volcanic Explosivity Index (VEI)

	VEI								
	0	1	2	3	4	5	6	7	8
Volume of Ejecta (m^3)	$<10^4$	10^4–10^6	10^6–10^7	10^7–10^8	10^8–10^9	10^9–10^{10}	10^{10}–10^{11}	10^{11}–10^{12}	$>10^{12}$
Eruption Column Height (km)	<0.1	0.1–1	1–5	3–15	10–25	>25			
Eruptive Style	<-----Hawaiian----->			<-----Vulcanian----->					
		<---Strombolian--->					<-----------Plinian---------->		
Duration of Continuous Blast (hours)		<------<1------>		<---1–6--->					
					<-----6–12----->		<-------->12-------->		

After Newhall and Self (1982).

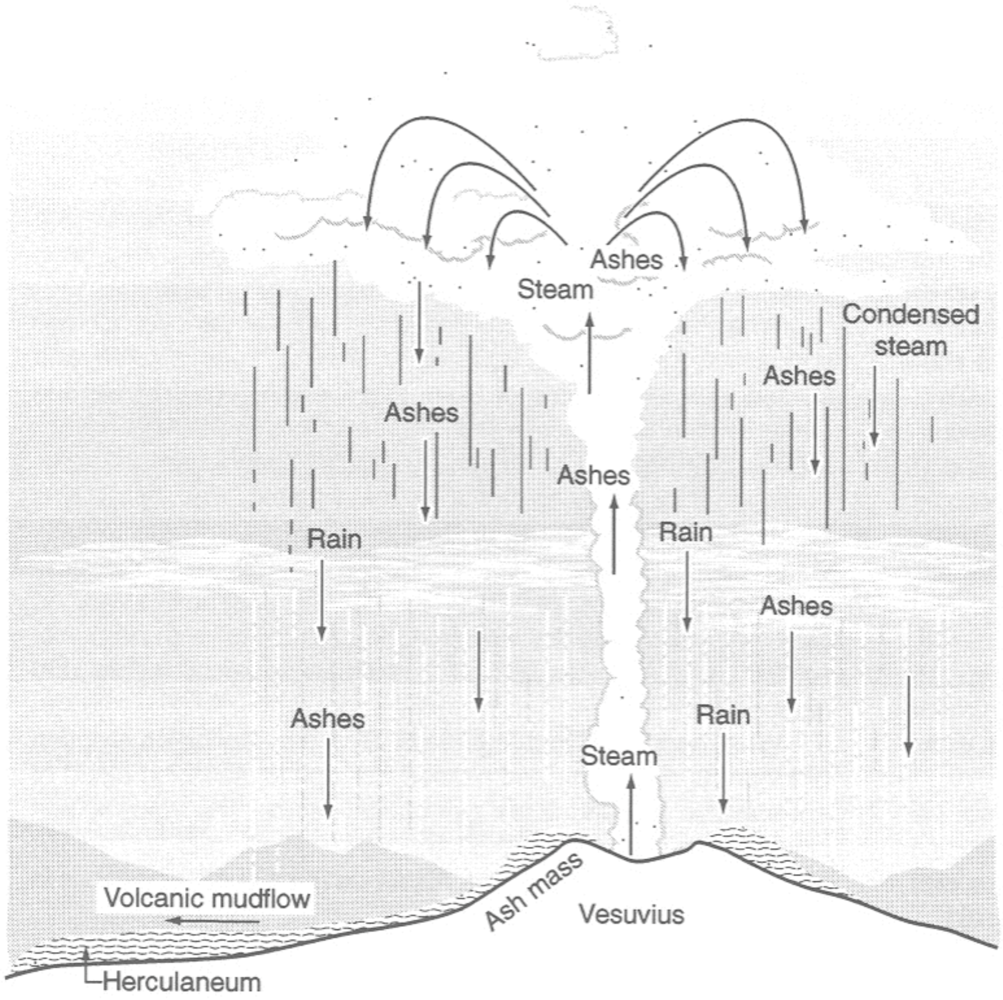


FIGURE 7.25
"Volcano weather" and formation of lahars. Prolonged vertical eruption leads to accumulation of debris on steep slopes of the volcano. Steam blown upward into cold, high altitudes condenses and falls back as rain. The stage is set: steep slopes + loose volcanic debris + heavy rain = lahars.

Remember this process for the Nevado Del Ruiz (1985) case study.

-what would the "rain" look like?

Accretionary lapilli are mud balls which result from a wet nucleus falling through a volcanic ash cloud. They flatten on striking the ground or may roll on loose ash and grow like a snowball.

Why are reactivated calderas so dangerous?

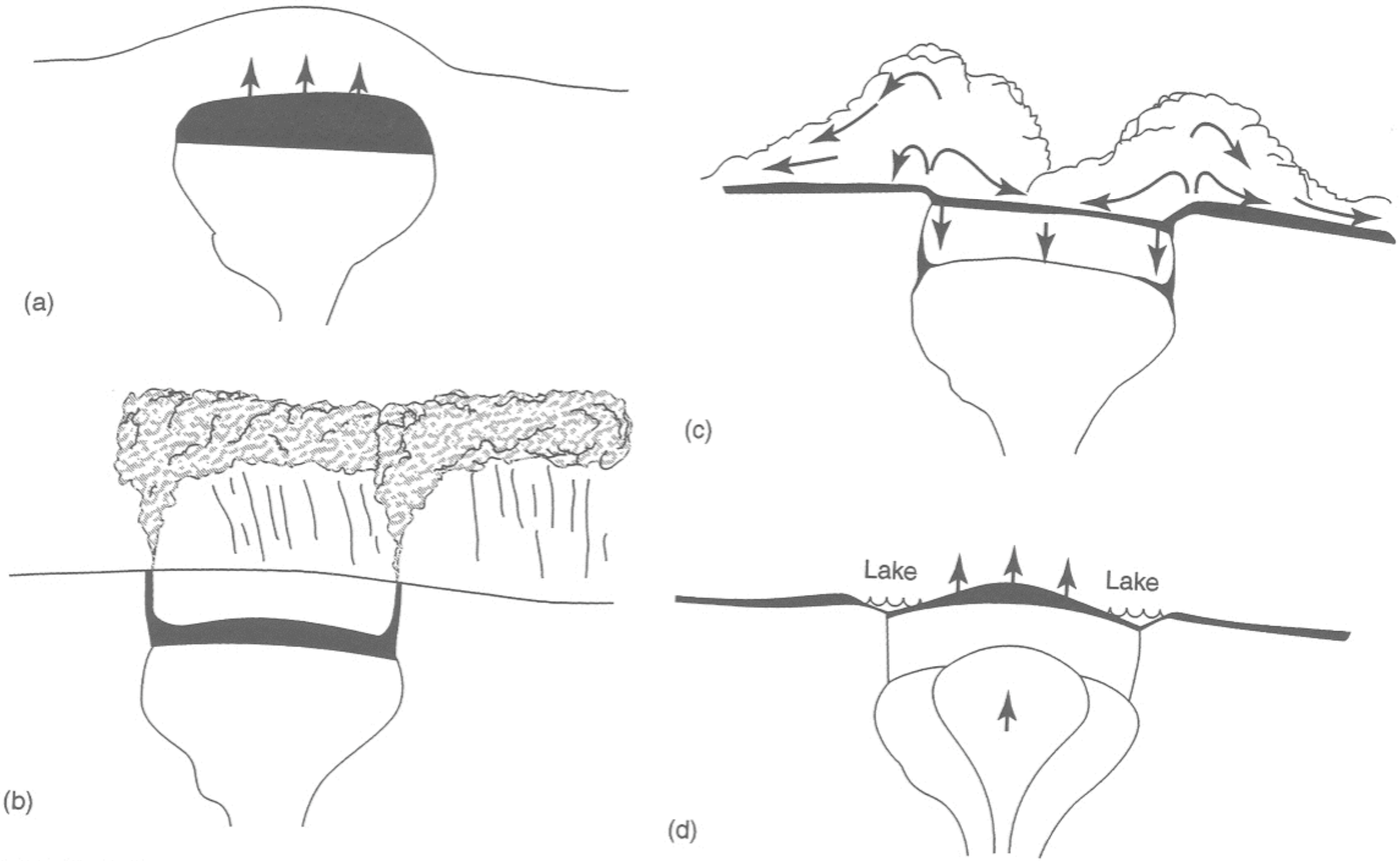


FIGURE 7.35

Stages in formation of a giant continental caldera. (a) Rising mass of magma forms low-density cap rich in SiO_2 and gases, bulging the ground surface upward. (b) Plinian eruptions begin from circular fractures surrounding the bulge. (c) Magma pours out in pyroclastic flows of tremendous volume, causing the ground surface to sink into a giant caldera. (d) Removal of magma decreases the crustal pressure, causing new magma to bulge up the caldera floor.

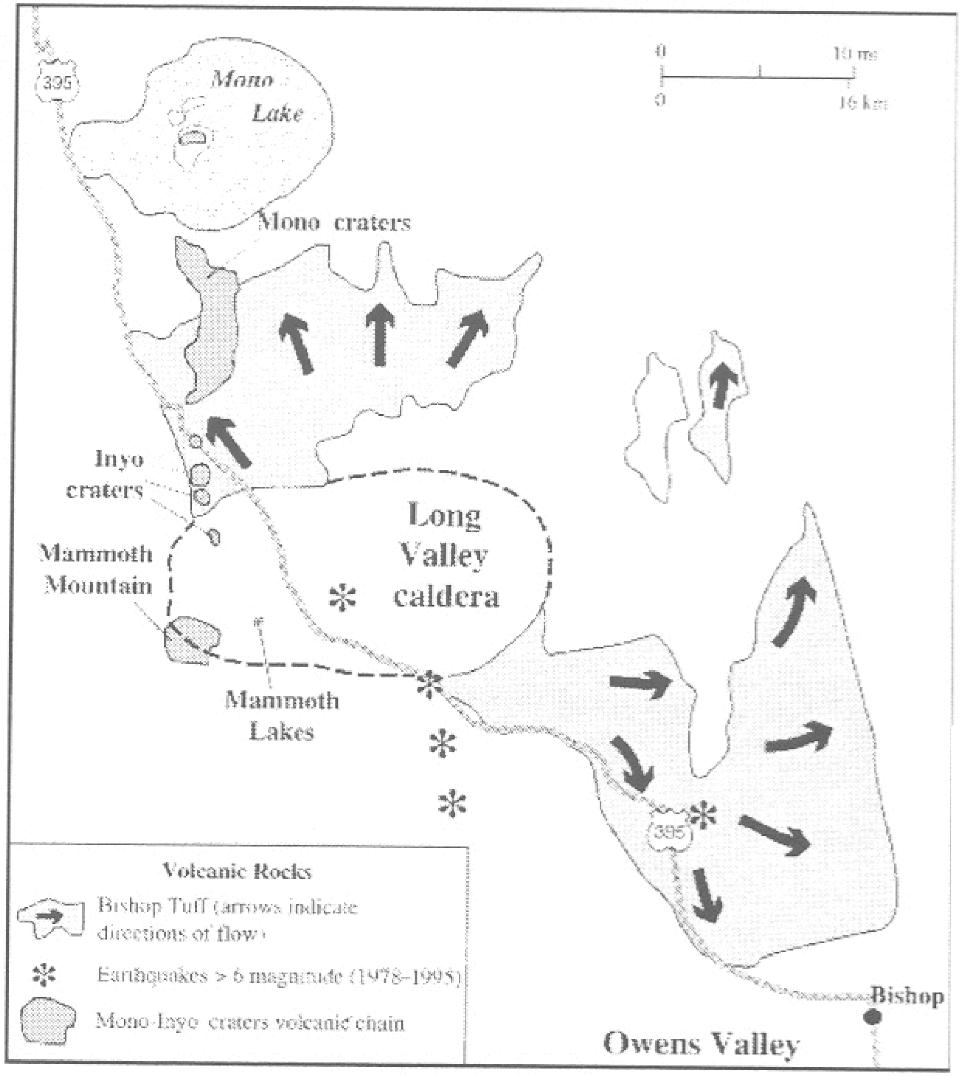
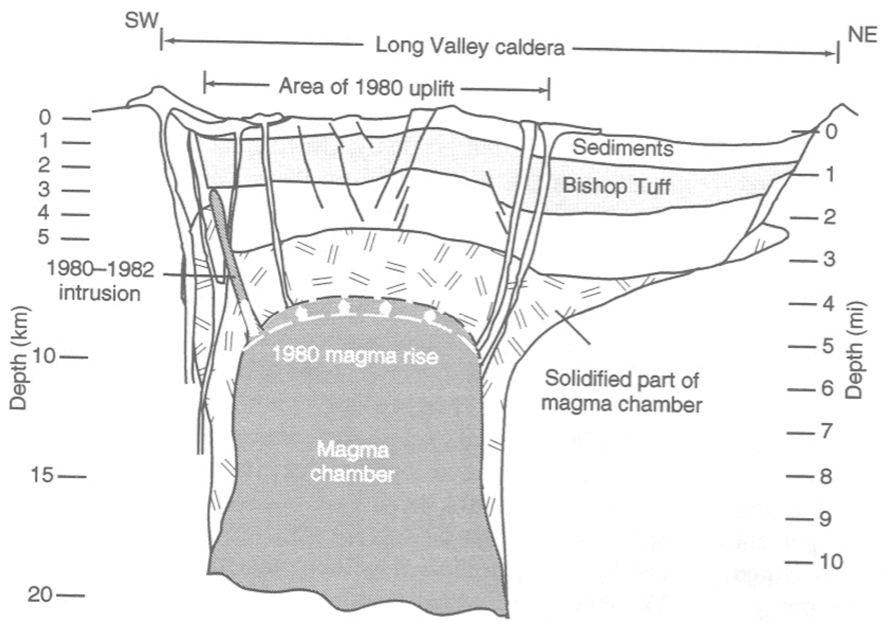


FIGURE 8.34

Map showing the Long Valley caldera formed by massive eruptions. Bishop Tuff is uneroded remains of pyroclastic debris from last major eruption. The section of Highway 395 shown here lies just north of the section pictured in figure 6.3.

Tuff: consolidated pyroclastic materials

1980 - activity renewed
1982 - USGS Notice of Potential Hazard



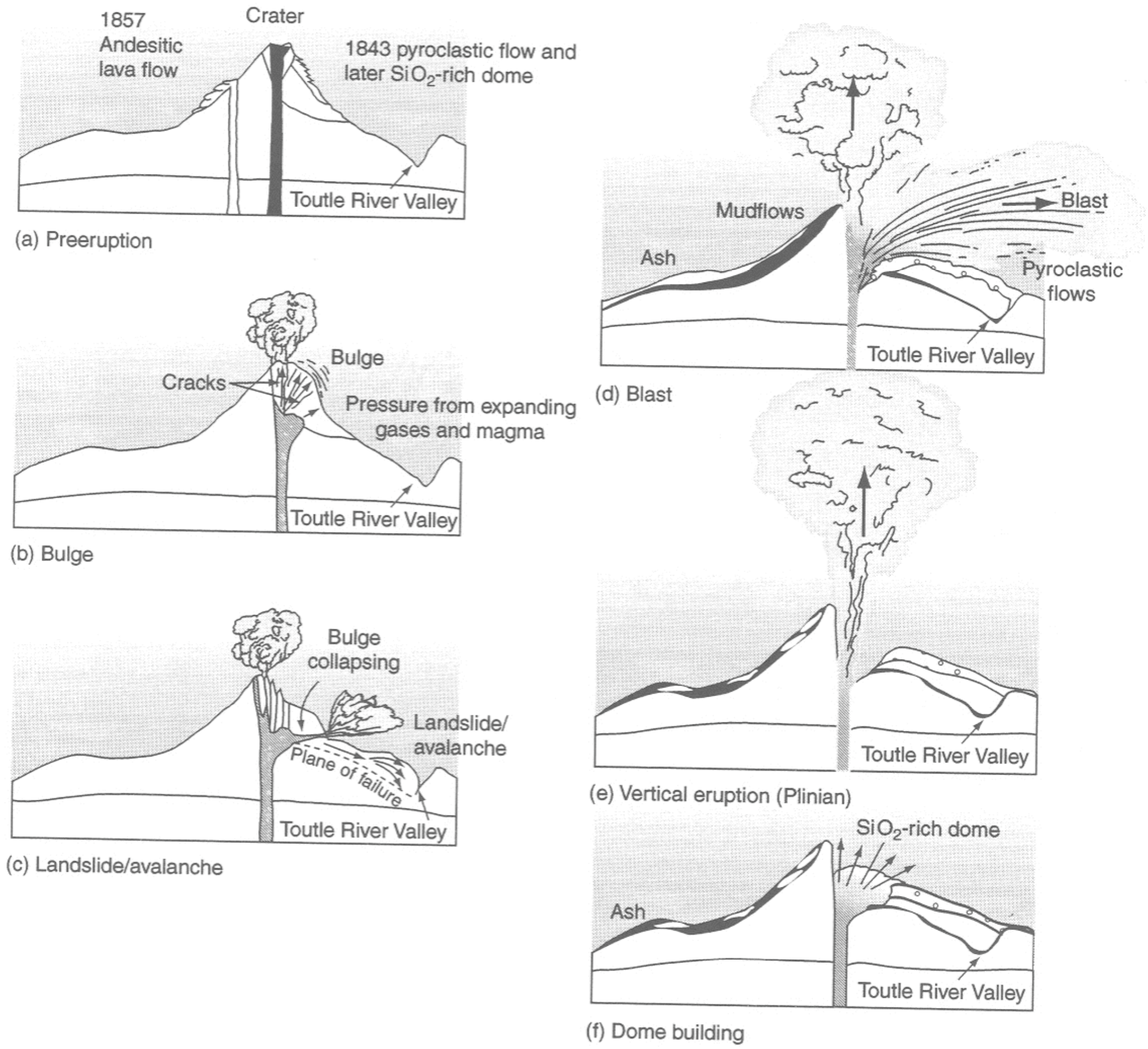


FIGURE 8.10

Eruptive sequence (VEI = 5) of Mount St. Helens in 1980. **(a)** The symmetrical volcanic cone was shaped in 1843 and 1857. **(b)** In late March, rising magma and expanding gases caused a growing bulge on the northern side. **(c)** At 8:32 A.M. on 18 May 1980, a magnitude 5.1 earthquake caused the bulge to fail in a massive landslide/avalanche. **(d)** The landslide released pressure on the near-surface body of magma, causing an instantaneous blast of fragmented rock and magma. **(e)** The "throat" of the volcano was now clear, and the vertical eruption of gases and small blobs of magma shot up to heights of more than 20 km (12 mi) for nine hours. **(f)** Today, the mountain is slowly rebuilding with a volcanic dome of SiO_2-rich magma.

Mt. St. Helens (1980) - similar to the Santa Maria, Guatemala eruption of 1902.

-what would be warning signs to monitor for these types of eruptions?

Last known Shasta eruption - 1786; recurrence interval of ~300-400 years

What's the problem with the hazard designations? ----------------->

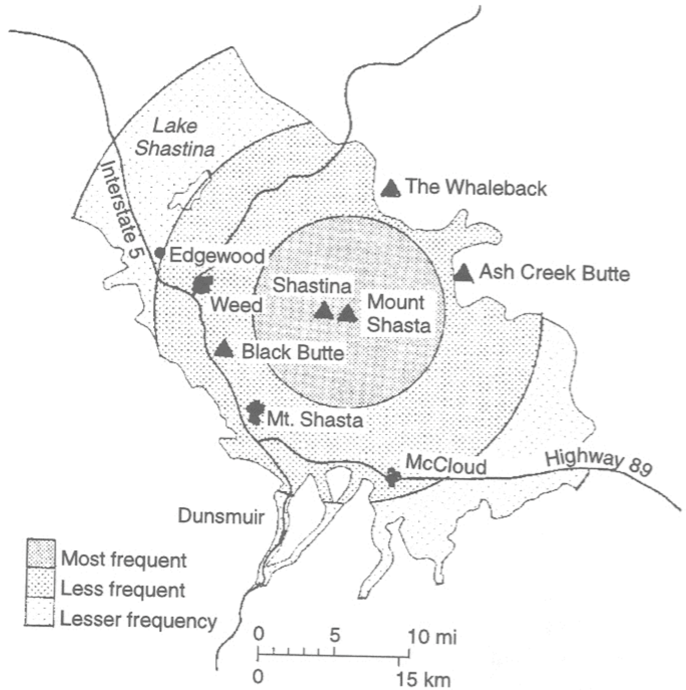


FIGURE 8.17

Map of Mount Shasta–Shastina region showing areas most susceptible to lateral blasts and pyroclastic flows. Note the growing towns within the danger zones.

Source: *D. R. Crandell and D. R. Nichols, "Volcanic Hazards at Mt. Shasta,"* 1989, U.S. Geological Survey.

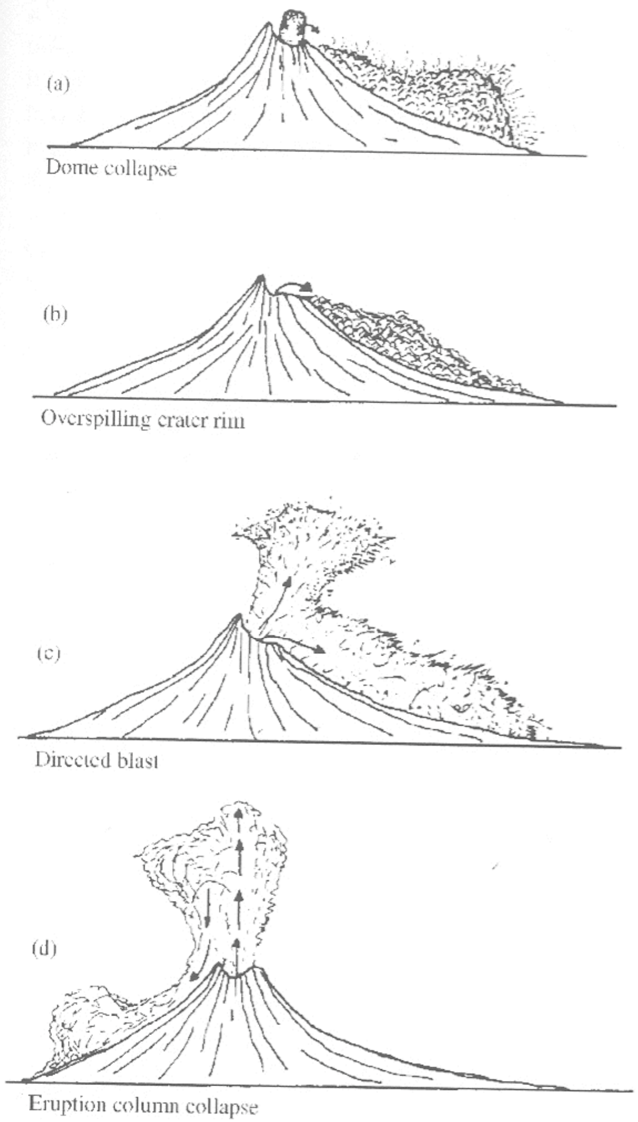


FIGURE 8.22

Ways of generating pyroclastic flows. (a) Dome collapse as at Mount Unzen, 1991; (b) Overspilling of crater rim as at Mont Pelée, 1902–1903; (c) Directed blast as at Mount St. Helens, 1980 and Mount Pinatubo, 1991; (d) Eruption column collapse as at Mount Mayon, 1968.

Pyroclastic flows - the most dangerous volcanic hazard; why?

-multiple formation processes
-will overflow and overshoot channels
-difficult to predict
-very rapid, so evacuation is required
-incredibly destructive

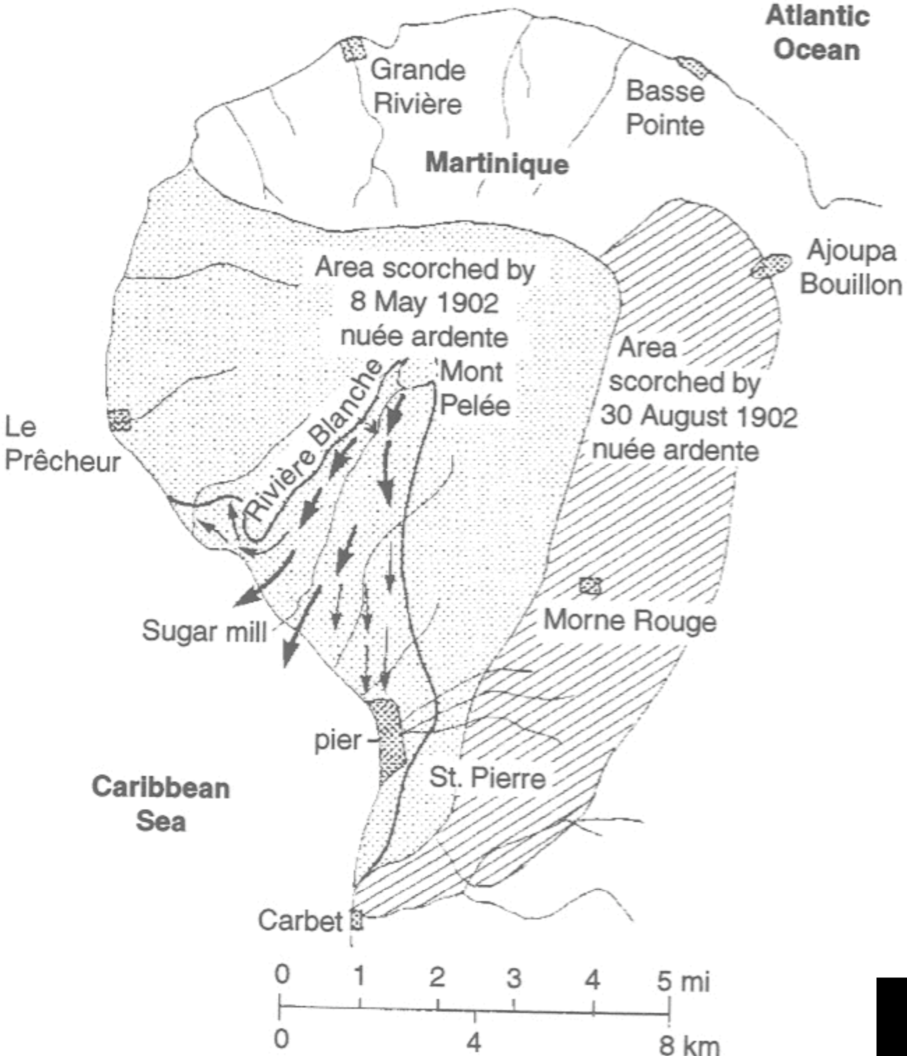


FIGURE 8.25

Map of Mont Pelée showing areas scorched by the largest nuée ardentes of 1902.

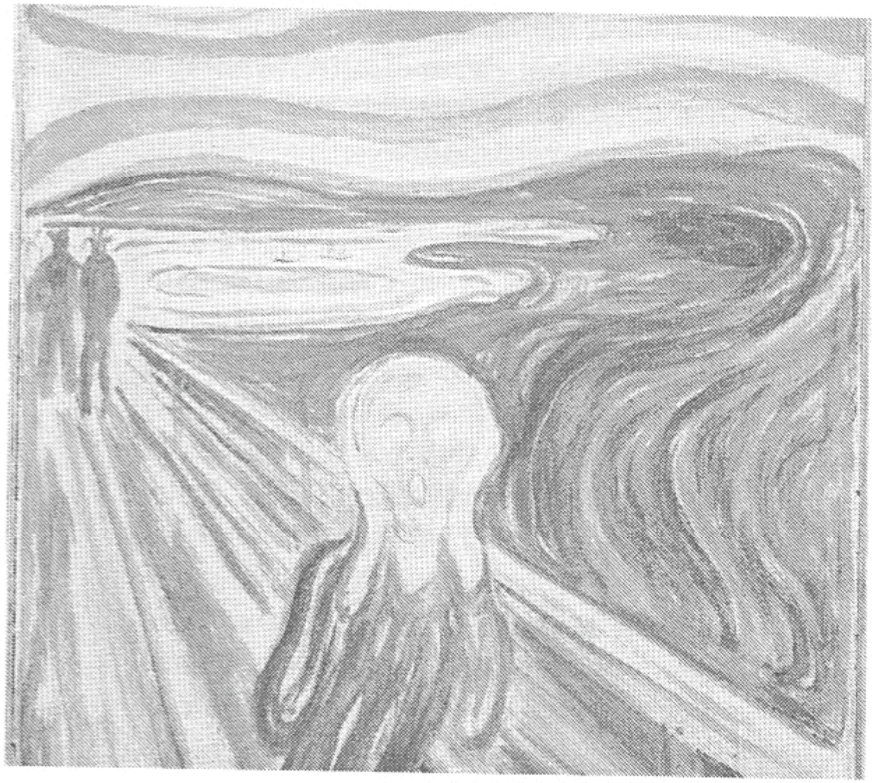


FIGURE 8.27

The Scream, painted by Edvard Munch, is thought to be his reaction to the skies made blood red in Europe by the Krakatau eruption.

See Scarth book: many myths perpetuated from this event