

Natural Disasters

Lecture 20

Ch 6 – Volcanic Eruptions: Plate Tectonics and Magmas

Text Source Today:
Chapter 6 (p. 157-172)

6.2: Ch. 6 – Volcanic Eruptions: Plate Tectonics and Magmas

♦ **Volcanic Explosivity Index (VEI):** includes:
 (1) **volume** of material erupted;
 (2) **how high** the eruption reached; and, (3) **how long** the major eruptive blast lasted

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Volcanic Explosivity Index (VEI)

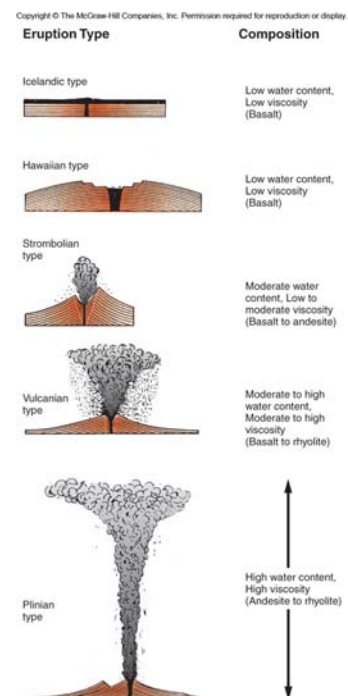
	0	1	2	3	4	5	6	7	8
Volume of ejecta (m ³)	<10 ⁶	10 ⁶ –10 ⁸	10 ⁸ –10 ⁹	10 ⁹ –10 ¹⁰	10 ¹⁰ –10 ¹¹	10 ¹¹ –10 ¹²	10 ¹² –10 ¹³	10 ¹³ –10 ¹⁴	>10 ¹⁴
Eruption column height (km)	<0.1	0.1–1	1–5	3–15	10–25	>25			
Eruptive style	Hawaiian		Strombolian		Vulcanian		Plinian		
Duration of continuous blast (hours)	<1		1–6		6–12		>12		

Source: After Newhall and Self (1982).

(Fig. 6.16)

● The VEI ranges from **0 to 8**; examples:

- 0:** Kilauea, Hawaii, 1983 to present
- 1:** Stromboli, Italy, 1996
- 2:** Unzen, Japan, 1994
- 3:** Nevado del Ruiz, Columbia, 1985
- 4:** El Chichon, Mexico, 1982
- 5:** St. Helens, WA, 1980
- 6:** Pinatubo, Indonesia, 1991
 Krakatau, Indonesia, 1883
 Vesuvius, Italy, 79 CE
 Thera (Santorini), Greece, 1628 BCE
- 7:** Tambora, Indonesia, 1815
- 8:** Toba, Indonesia, ~73,000 BCE
 Yellowstone, Wyoming, ~640,000 BCE



♦♦ The “Three Vs” - Viscosity, Volatiles, Volume:

- **Viscosity:** controls whether magma **flows away or piles up**
- **Volatiles:** may ooze out **harmlessly or blast out explosively**
- **Volume:** the **greater** the volume, the more **intense the eruption**

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TABLE 6.7

Eruption Styles and Explosiveness

Eruption Style	Viscosity	Volatiles	Volcanic Explosivity Index
Icelandic	Low	Low	0–1 (very low)
Hawaiian	Low	Low	0–1 (very low)
Strombolian	Moderate	Moderate	1–3 (low)
Vulcanian	High	High	2–5 (high)
Plinian	High	High	3–8 (very high)

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TABLE 6.8

Volcanism Control by the Three Vs (Viscosity, Volatiles, Volume)

Viscosity	+	Volatiles	+	Volume	=	Volcanic Landforms
Low		Low		Large		Shield volcanoes
Low		Low		Very large		Flood basalts
Low/medium		Medium/high		Small		Scoria cones
Medium/high		Medium/high		Large		Stratovolcanoes
High		Low		Small		Lava domes
High		High		Very large		Calderas

♦♦ **Shield Volcanoes:** **low** viscosity, **low** volatiles, **large** volume; **basaltic lava** flows cool to form a volcano that is much **wider than it is tall**

♦ **Hawaiian-type:** commonly preceded by a **series of EQs**, as rock fractures and moves out of the way for swelling magma; escaping gases can create a **“curtain of fire” (lava fountains)**, followed by basaltic lava spilling out of fissures and down mountain slopes as **red-hot rivers**



- Although **few lives are lost** in these eruptions, the lava flows engulf and incinerate buildings, bury highways, and cause drops in property value of homes near the latest flow

- If **H₂O** gets incorporated into the magma, a high-speed **base surge explosion** of superheated steam can prove deadly; 1790

♦ **Icelandic-type:** the **most peaceful** eruptions on Earth; referred to as **fissure** eruptions, as the basaltic lava pours out of linear vents or long fractures, shooting upwards as a **“curtain of fire”** with varying intensities and heights, almost “water-like”



♦♦ **Flood Basalts:** **low** viscosity, **low** volatiles, **very large** volume; the **largest** volcanic events known on Earth!

- Pour **immense amounts** of mass and energy onto Earth's surface, over a **large region**, in a relatively brief geologic time span of 1-3 million years
- Occur on all continents and on all ocean floors; **none** has occurred in historic times



♦ Emit tons of **climate-modifying volatiles**, such as **CO₂** and **SO₂**, and have been linked to **mass extinctions**!

♦♦ **Scoria (Cinder) Cones:** **low/medium** viscosity, **medium/high** volatiles, **small** volume; are conical hills, of **low height**.



♦ **Strombolian-type:** formed by **basaltic to andesitic** pyroclastic debris piled up next to a volcanic vent, and typically has a summit crater, with a lava lake during eruption

- Eruption can last from few hours to several years, but once the eruption ceases, it usually **does not erupt again**

♦ **Stromboli, Italy** is the most active volcano on Earth, having nearly daily eruptions for millennia



- On 20 February 1943, near **Paricutin, Mexico**, a new volcano blasted up through a farm field and erupted for the next 9 years; pyroclastic debris and lava flows destroyed the two nearby towns

♦♦ Stratovolcanoes (composite):

medium/high viscosity, **medium/high** volatiles, **large** volume; are steep-sided, symmetrical volcanic peaks built of alternating layers of pyroclastic debris successively capped by high-viscosity **andesitic to rhyolitic** lava flows that solidify to form **protective caps**



(Fig. 6.28)

♦ **Vulcanian-type:** eruptions alternate between thick, highly viscous **lavas** and masses of **pyroclastic material** blown out of the volcano; can be the early phase in the eruptions of other volcanoes, as they “**clear their throat**” before larger eruptions

♦ **Plinian-type:** “throat is now clear” and incredible gas-powered **vertical eruption columns** carry pyroclastic debris, including lots of pumice, up to **50 km (30 miles)** into the atmosphere! ♦ Examples: **Vesuvius, 79 CE** and **Pinatubo, 1991**



● Is a common final phase in a major eruptive sequence; about 2-3 Plinian eruptions occur each century



♦ The high-speed (100-150 mph), gas-charged, **superhot** (600-850° C; 1100-1550 ° F), **pyroclastic flows** can be sudden and deadly

● **Ash fall** can be substantial, making the countryside monochromatic and crushing buildings with its heavy accumulated weight



♦ **Heavy rain** falling on thick piles of pyroclastic debris can create a **lahar (volcanic mudflow)**

♦♦ **Lava Domes:** **high** viscosity, **low** volatiles, **small** volume; the magma cools quickly, producing a **hardened dome or plug** in as little as a **few hours** or grow for decades



- After a major eruption, the high-viscosity, low-volatile “paste” that is left over, oozes upward **slowly**, cools **quickly**, and forms a **“plug in the throat”** of the volcano

- **Volcanic sequence:** a **Vulcanian** precursor, a **Plinian** main event, and a **lava dome** conclusion

♦♦ **Calderas:** **high** viscosity, **high** volatiles, **very large** volume; these eruptions are the largest of the violent, explosive volcanic behaviors!



- **Calderas** form by **inward collapse**: (1) at summits of shield volcanoes (Kilauea, HI); (2) at summits of stratovolcanoes (Crater Lake, OR, Krakatau, Indonesia, Santorini, Greece); and, (3) **giant continental calderas** (Yellowstone, WY, Long Valley, CA, Valles, NM). Through time, a central raised area may form, as magma returns, and is called a **resurgent caldera**.

♦ **Ultra-Plinian-type:** huge volumes of magma pour out in **short amounts** of time, with **extra-high** ash columns and widespread sheets of outward-flowing **ash and pumice**.

- **Catastrophically** changes global climate for the **worse!**
- **Yellowstone, WY**, a resurgent caldera above a continental hot spot, erupted 2 million, 1.3 million and 0.6 million years ago
- Most “recent” was **Toba on Sumatra**, Indonesia, ~74,000 years ago

- **Volcanism and Climate:** major volcanic eruptions have **altered climate patterns**, some for short periods of time and others for many years, perhaps causing mass extinctions.



- Principle factors include:
 - (1) The **size and rate** of eruptions;
 - (2) The **heights** of eruption columns;
 - (3) The **types of gases** and the atmospheric level they are placed (SO_2 in the stratosphere reflect sunlight and causes **cooling**; CO_2 in the atmosphere creates a **warming** greenhouse effect);
 - (4) **Low-latitude** eruptions spread atmospheric debris across more of the world and have greater global effects than **high-latitude** eruptions.

- ◆ **Worst-case scenario** for volcanic effects on climate?

Flood basalt volcanism, linked directly to mass extinctions!