


1  **Volcanoes & Other Igneous Activity**

Earth 9th edition – Chapter 5

2  **Volcanoes: summary in haiku form**

A volcano forms.
Magma comes to the surface -
explodes, if felsic.

3  **Key Concepts**

- Factors that determine the nature of volcanic eruptions.
- Materials associated with volcanic eruptions.
- Types of volcanoes and styles of eruption.
- Landforms associated with volcanoes and volcanic terrains.
- Classification of igneous rock bodies.
- Volcanoes and plate tectonics.
- The relation between volcanoes and climate change.

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7  **From the VolcanoCam, 12 September 2007**

8  **The nature of volcanic eruptions**

- Characteristics of a magma determine the “violence” or explosiveness of a volcanic eruption
 1. Composition
 2. Temperature
 3. Dissolved gases
- The above three factors actually control the viscosity of a given magma

9  **The nature of volcanic eruptions**

- Viscosity is a measure of a material's resistance to flow
- Factors affecting viscosity
 - ☒ Temperature - Hotter magmas are less viscous
 - ☒ Composition - Silica (SiO₂) content
 - ◆ Higher silica content = higher viscosity (e.g., felsic lava such as rhyolite)
 - ◆ Lower silica content = lower viscosity (e.g., mafic lava such as basalt)

10  **The nature of volcanic eruptions**

- ☒ Dissolved gases
 - ◆ Gas content affects magma mobility
 - ◆ Gases expand within a magma as it nears the Earth's surface due to decreasing pressure
 - ◆ The violence of an eruption is related to how easily gases escape from magma
- ☒ In summary
 - ◆ Basaltic lavas = mild eruptions
 - ◆ Rhyolitic or andesitic lavas = explosive eruptions

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12  **Materials extruded from a volcano**

- Lava flows
 - ◆ Basaltic lavas exhibit fluid behavior
 - ◆ Types of basaltic flows
 - Pahoehoe lava (resembles a twisted or ropey texture)
 - Aa lava (rough, jagged blocky texture)
- Dissolved gases
 - ◆ 1% - 6% by weight

- ◆ Mainly H₂O and CO₂
- 13 **A pahoehoe lava flow**
- 14 **Aa lava flow**
- 15 **Materials extruded from a volcano**
 - Pyroclastic materials – “fire fragments”
 - Types of pyroclastic debris
 - ◆ Ash and dust - fine, glassy fragments
 - ◆ Pumice - porous rock from “frothy” lava
 - ◆ Cinders - pea-sized material
 - ◆ Lapilli - walnut-sized material
 - ◆ Particles larger than lapilli
 - Blocks - hardened or cooled lava
 - Bombs - ejected as hot lava
- 16 **A volcanic bomb**
- 17 **A volcanic bomb in Mojave Preserve**
- 18 **General features of Volcanoes**
 - ☒ Opening at the summit of a volcano
 - ◆ Crater - summit depression < 1 km diameter
 - ◆ Caldera - summit depression > 1 km diameter produced by collapse following a massive eruption
 - ☒ Vent – surface opening connected to the magma chamber
 - ☒ Fumarole – emit only gases
- 19 **General features of Volcanoes**
 - Types of volcanoes
 - ☒ Shield volcano
 - ◆ Broad, slightly domed-shaped
 - ◆ Generally cover large areas
 - ◆ Produced by mild eruptions of large volumes of basaltic lava
 - ◆ Example = Mauna Loa on Hawaii
- 20 **Anatomy of a shield volcano**
- 21
- 22 **General features of Volcanoes**
 - Types of volcanoes (continued)
 - ☒ Cinder cone
 - ◆ Built from ejected lava (mainly cinder-sized) fragments
 - ◆ Steep slope angle
 - ◆ Small size
 - ◆ Frequently occur in groups
- 23 **Cinder cone volcano**
- 24 **Vulcan's Throne, a cinder cone**
- 25 **Red Hill and lava flow**
- 26 **General features of Volcanoes**
 - Types of volcanoes (continued)
 - ☒ Composite cone (stratovolcano)
 - ◆ Most are located adjacent to the Pacific Ocean (e.g., Fujiyama, Mt. St. Helens)
 - ◆ Large, classic-shaped volcano (1000's of ft. high and several miles wide at base)
 - ◆ Composed of interbedded lava flows and pyroclastic debris
 - ◆ Most violent type of activity (e.g., Mt. Vesuvius)
- 27 **Anatomy of a composite volcano**
- 28 **Mt. Shasta, California**
- 29 **Mt. Rainier, Washington**

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Profiles of volcanic landforms

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Volcanic Hazards

- Nuée ardente – A deadly pyroclastic flow
 - Fiery pyroclastic flow made of hot gases infused with ash and other debris
 - Also known as glowing avalanches
 - Move down the slopes of a volcano at speeds up to 200 km per hour
- Lahar – volcanic mudflow
 - Mixture of volcanic debris and water
 - Move down stream valleys and volcanic slopes, often with destructive results

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A nueé ardente on Mt. St. Helens

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Volcanic landforms

- Caldera
 - Steep-walled depressions at the summit
 - Generally > 1 km in diameter
 - Produced by collapse
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- Caldera Types
 - Crater Lake – Type
 - Hawaiian – Type
 - Yellowstone - Type

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Formation of Crater Lake, Oregon

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Crater Lake and Wizard Island, 2001

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Halemaumau, within Kilauea Caldera

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Yellowstone-type Caldera formation

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Yellowstone-type Caldera formation

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Yellowstone-type Caldera formation

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Yellowstone-type Caldera formation

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Other volcanic landforms

- Fissure eruptions and lava plateaus
 - Fluid basaltic lava extruded from crustal fractures called fissures
 - Example = Columbia River Plateau
- Lava domes
 - Bulbous mass of congealed lava
 - Associated with explosive eruptions of gas-rich magma

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Track of the Yellowstone Hot-spot

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A lava dome

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Salton Buttes:

lava domes in our back yard...

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Obsidian Butte, a lava dome

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Other volcanic landforms

- Volcanic pipes and necks
 - Pipes - short conduits that connect a magma chamber to the surface
 - Include kimberlite pipes
 - Volcanic necks (e.g., Ship Rock, New Mexico) - resistant vents left standing after erosion has removed the volcanic cone

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Kimberly, South Africa

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Shiprock, New Mexico

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Formation of a volcanic neck

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Devil's Tower, Wyoming

- 54  **Extrusive igneous activity**
- Types of extrusive igneous features
 - ☒ Pillow lavas
 - ◆ Result from lava flowing into a body of water
 - ☒ Columnar jointing
 - ◆ Hexagonal columns as a result of cooling and contracting
- 55  ***Pillow Lavas in the Grand Canyon***
- 56  **Columnar Jointing in the Grand Canyon**
- 57  **Intrusive igneous activity**
- Most magma is emplaced at depth in the Earth
 - ☒ Once cooled and solidified, is called a pluton
 - Nature of plutons
 - ☒ Shape - tabular (sheetlike) vs. massive
 - ☒ Orientation with respect to the host (surrounding) rock
 - ◆ Concordant vs. discordant
- 58  **Intrusive igneous activity**
- Types of intrusive igneous features
 - ☒ Dike – a tabular, discordant pluton
 - ◆ Rancho San Marcos Dike Swarm, B.C., Mexico
 - ☒ Sill – a tabular, concordant pluton
 - ◆ (e.g., Palisades Sill in New York)
 - ☒ Laccolith
 - ◆ Similar to a sill
 - ◆ Lens or mushroom-shaped mass
 - ◆ Arches overlying strata upward
- 59  **Igneous structures**
- 60  **Dikes near Ojos Negros, B.C.**
- 61  **Basalt Dikes in the Grand Canyon**
- 62  **A sill in the Salt River Canyon, Arizona**
- 63  **Intrusive igneous activity**
- Intrusive igneous features continued
 - ☒ Batholith
 - ◆ Largest intrusive body
 - ◆ Surface exposure > 100+ km² (smaller bodies are termed stocks)
 - ◆ Frequently form the cores of mountains
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- 65  **Plate tectonics and igneous activity**
- Global distribution of igneous activity is not random
 - ☒ Most volcanoes are located within or near ocean basins
 - ☒ Basaltic rocks = oceanic and continental settings
 - ☒ Granitic rocks = continental settings
- 66  **Distribution of some of the world's major volcanoes**
- 67  **Plate tectonics and igneous activity**
- Igneous activity at plate margins
 - ☒ Spreading centers
 - ◆ Greatest volume of volcanic rock is produced along the oceanic ridge system
 - ◆ Mechanism of spreading
 - Decompression melting of the mantle occurs as the lithosphere is pulled apart
 - Large quantities of basaltic magma are produced
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69 **Plate tectonics and igneous activity**

- Subduction zones
 - Occur in conjunction with deep oceanic trenches
 - Partially melting of descending plate and upper mantle
 - Rising magma can form either
 - An island arc if in the ocean
 - A volcanic arc if on a continental margin
 - Associated with the Pacific Ocean Basin
 - Region around the margin is known as the "Ring of Fire"
 - Majority of world's explosive volcanoes

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73 **Plate tectonics and igneous activity**

- Intraplate volcanism
 - Occurs within a tectonic plate
 - Associated with mantle plumes
 - Localized volcanic regions in the overriding plate are called a hot spot
 - Produces basaltic magma sources in oceanic crust (e.g., Hawaii and Iceland)
 - Produces granitic magma sources in continental crust (e.g., Yellowstone Park)

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80 **Volcanoes and climate**

- The basic premise
 - Explosive eruptions emit huge quantities of gases and fine-grained debris
 - A portion of the incoming solar radiation is reflected and filtered out
- Past examples of volcanism affecting climate
 - Toba, Sumatra – 75,000 yrs B.P.
 - Mount Tambora, Indonesia – 1815
 - Krakatau, Indonesia – 1883

81 **End of the Road (and Chapter)**