Essentials of Geology, 11e

Volcanoes and Volcanic Hazards
Chapter 4

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The Nature of Volcanic Eruptions

- Factors determining the "violence" or explosiveness of a volcanic eruption
  - Composition of the magma
  - Temperature of the magma
  - Dissolved gases in the magma
- The above three factors control the viscosity of a given magma, which in turn controls the nature of an eruption

The Nature of Volcanic Eruptions

- Viscosity is a measure of a material's resistance to flow (e.g., higher viscosity materials flow with greater difficulty)
- 3 Factors affecting viscosity:
  - Temperature – hotter magmas are less viscous
  - Composition – silica (SiO_2) content
    - Higher silica content = higher viscosity (e.g., felsic lava such as rhyolite)
    - Lower silica content = lower viscosity or more fluid-like behavior (e.g., mafic lava such as basalt)

The Nature of Volcanic Eruptions

- 3 Factors affecting viscosity
  - 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

The Nature of Volcanic Eruptions

- Factors affecting viscosity

  In summary-
  - Fluid basaltic lavas generally produce quiet eruptions
  - Highly viscous lavas (rhyolite or andesite) produce more explosive eruptions
- Dissolved Gases
  - One to six percent of a magma by weight
  - Mainly water vapor and carbon dioxide

Extruded Materials

- Lava flows
  - Basaltic lavas are much more fluid
    - Pahoehoe lava (resembles a twisted or ropey texture)
    - Aa lava (rough, jagged blocky texture)

Figure 4.6 A

Lava Tube

Figure 4.7 A

Pyroclastic Materials

- **Pyroclastic materials** – "Fire fragments"
  - Types of pyroclastic debris
    - **Ash and dust** - fine, glassy fragments
    - **Pumice** - porous rock from "frothy" lava
    - **Lapilli** - walnut-sized material
    - **Cinders** - pea-sized material
    - Particles larger than lapilli
      - **Blocks** - hardened or cooled lava
      - **Bombs** - ejected as hot lava

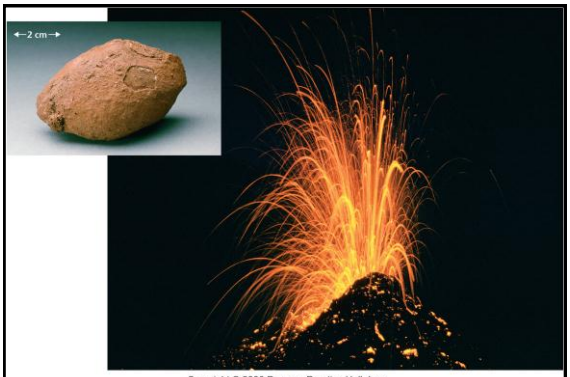

Figure 4.9

Volcanoes

- General features
  - Opening at the summit of a volcano
    - **Crater** – steep-walled depression at the summit, generally less than 1 kilometer in diameter
    - **Caldera** – a summit depression typically greater than 1 kilometer in diameter, produced by collapse following a massive eruption
  - **Vent** – opening connected to the magma chamber via a pipe

Volcanoes

- 3 Types of volcanoes
  - **Shield volcano**
    - Broad, slightly dome-shaped
    - Composed primarily of basaltic lava
    - Generally cover large areas
    - Produced by mild eruptions of large volumes of lava
    - Mauna Loa on Hawaii is a good example

Mauna Loa – a shield volcano

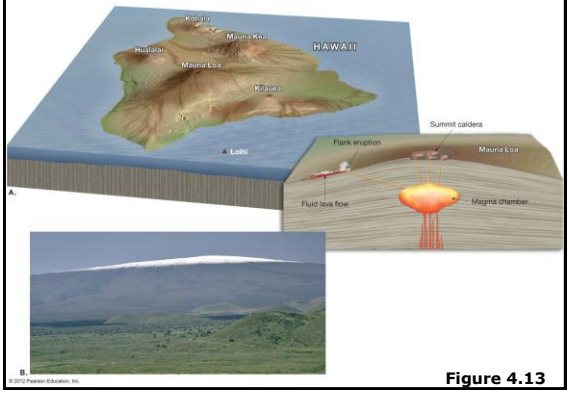

Figure 4.13

Volcanoes

- Types of volcanoes
  - Cinder cone
    - Built from ejected lava (mainly cinder-sized) fragments
    - Steep slope angle
    - Rather small size
    - Frequently occur in groups

Sunset Crater

A cinder cone near Flagstaff, Arizona

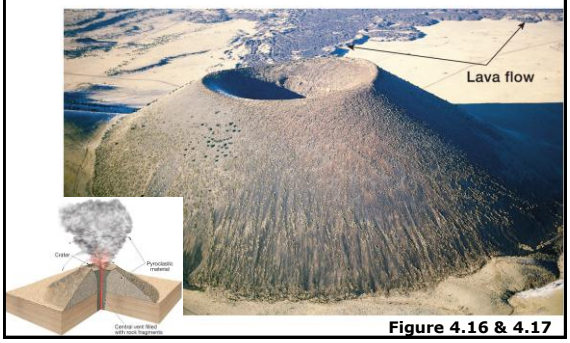

Figure 4.16 & 4.17

Volcanoes

- Types of volcanoes
  - Composite cone (stratovolcano)
    - Most are located adjacent to the Pacific Ocean (e.g., Fujiyama, Mount St. Helens)
    - Large, classic-shaped volcano (thousands of feet high and several miles wide at base)
    - Composed of interbedded lava flows and layers of pyroclastic debris

Volcanoes

- Composite cones, continued
  - Most violent type of activity (e.g., Mt. Vesuvius)
  - Often produce a pyroclastic flow
    - Fiery pyroclastic flow made of hot gases infused with ash and other debris
    - Move down the slopes of a volcano at speeds up to 200 km per hour
  - May produce a lahar, which is a volcanic mudflow

A Composite Volcano

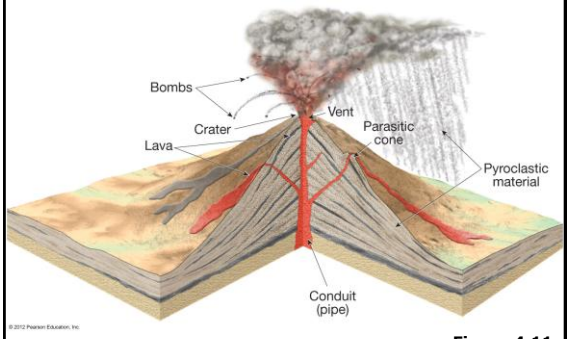

Figure 4.11

A Pyroclastic Flow - Mt. Unzen

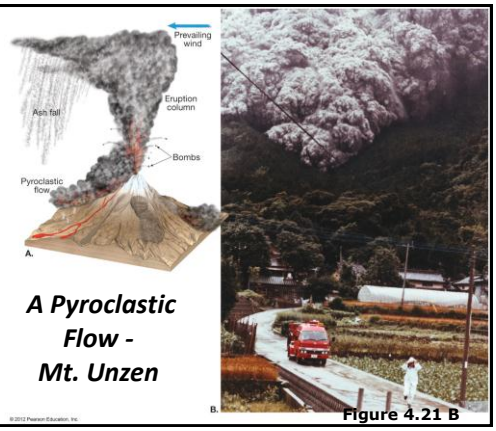

Figure 4.21 B

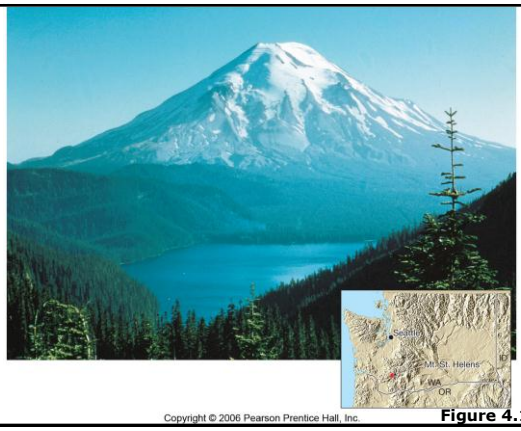

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Figure 4.1

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Figure 4.20, 10th ed

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Figure 4.1

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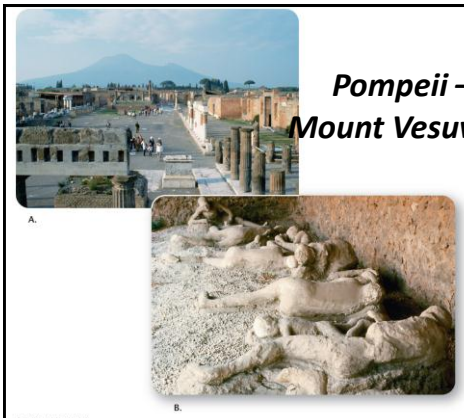
Figure 4.24



Pompeii – Mount Vesuvius

A Size Comparison of the Three Types

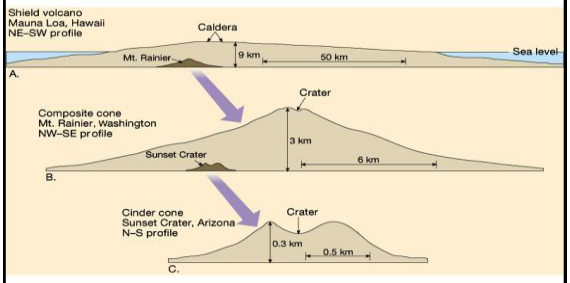


Figure 4.14

Other Volcanic Landforms

- **Calderas**
  - Steep-walled depressions at the summit
  - Size generally exceeds 1 kilometer in diameter
- **Pyroclastic flows**
  - Associated with felsic and intermediate magma
  - Consist of ash, pumice, and other fragmental debris
  - Material is propelled from the vent at a high speed

Figure 4.22, 10th ed

Crater Lake, Oregon

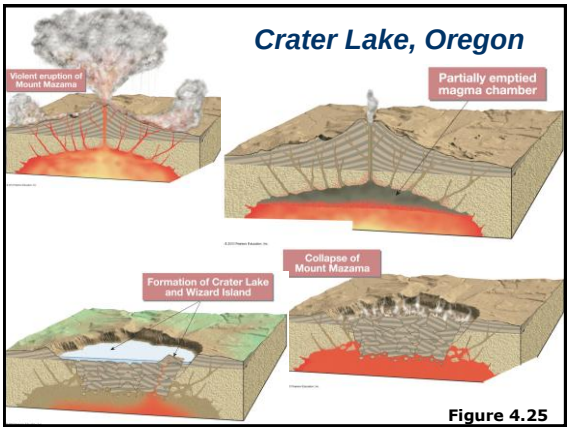
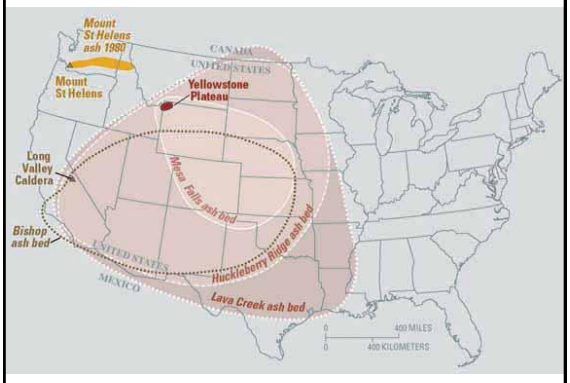
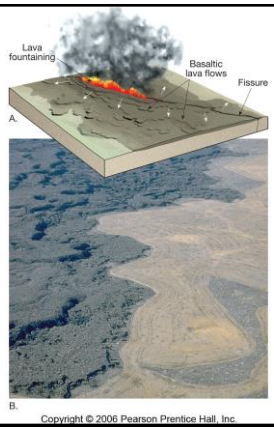


Figure 4.25



Other Volcanic Landforms

- **Fissure eruptions and lava plateaus**
  - Fluid basaltic lava extruded from crustal fractures called fissures
  - e.g., Columbia River Plateau
- **Lava Domes**
  - Bulbous mass of congealed lava
  - Most are associated with explosive eruptions of gas-rich magma



The Columbia River basalts

Figure 4.27

The Columbia River Basalts

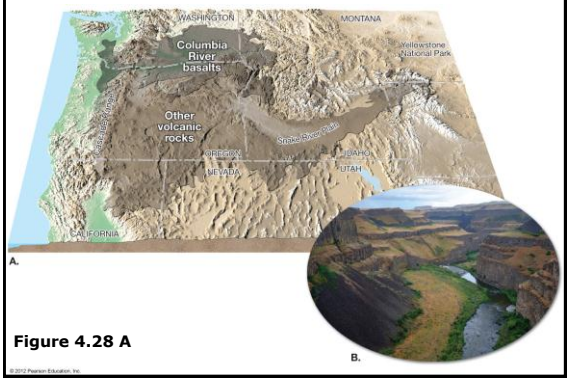
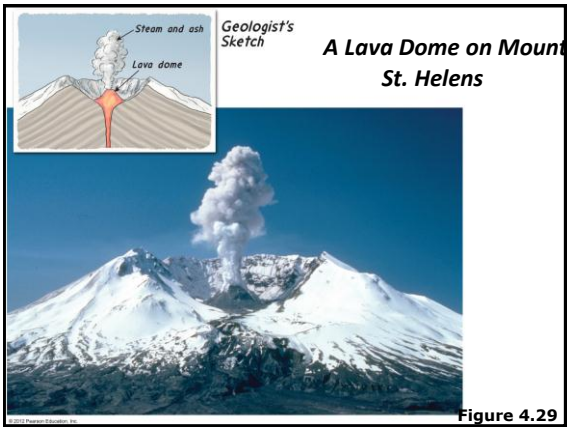


Figure 4.28 A

Other Volcanic Landforms

- **Lava domes**
  - **Bulbous masses of congealed lava**
  - **Most are associated with explosive eruptions of gas-rich magma**
- **Volcanic pipes and necks**
  - **Pipes are short conduits that connect a magma chamber to the surface**



A Lava Dome on Mount St. Helens

Figure 4.29

Other Volcanic Landforms

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

Formation of a Volcanic Neck

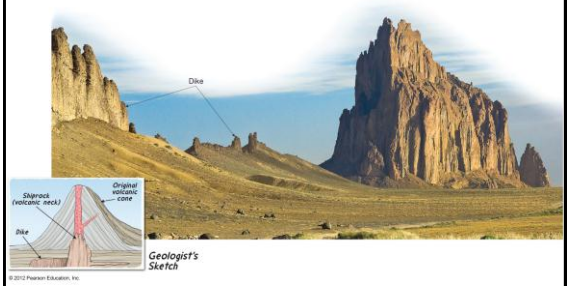


Figure 4.31

Plate Tectonics and Igneous Activity

- **Global distribution of igneous activity is not random**
  - **Most volcanoes are located within or near ocean basins**
  - **Basaltic rocks are common in both oceanic and continental settings, whereas granitic rocks are rarely found in the oceans**
  - **Active volcanoes are often associated with plate boundaries**

Distribution of Some of the World's Major Volcanoes

Figure 4.32

Plate Tectonics and Igneous Activity

- **Igneous activity along plate margins**
  - **Spreading centers**
    - **The greatest volume of volcanic rock is produced along the oceanic ridge system**
    - **Mechanism of spreading-**
      - » **Lithosphere pulls apart**
      - » **Less pressure on underlying rocks**
      - » **Results in partial melting of mantle**
      - » **Large quantities of basaltic magma are produced**

Plate Tectonics and Igneous Activity

- **Igneous activity along plate margins**
  - **Subduction zones**
    - **Occurs with deep oceanic trenches where descending plate partially melts**
    - **Magma slowly moves upward**
    - **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. Many explosive volcanoes.**

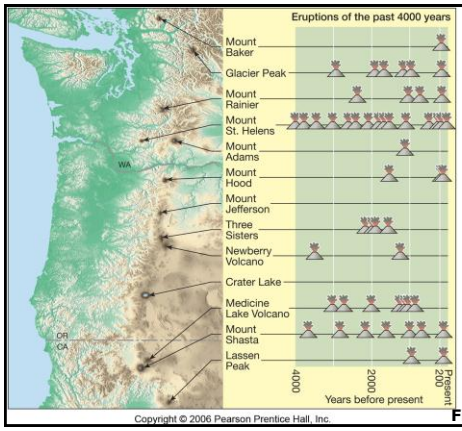


Figure 4.20

Plate Tectonics and Igneous Activity

- **Intraplate volcanism**
  - **Activity within a tectonic plate, associated with plumes of heat in the mantle**
  - **Forms localized volcanic regions in the overriding plate 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)**

Volcanism on a Tectonic Plate Moving Over a Hot Spot

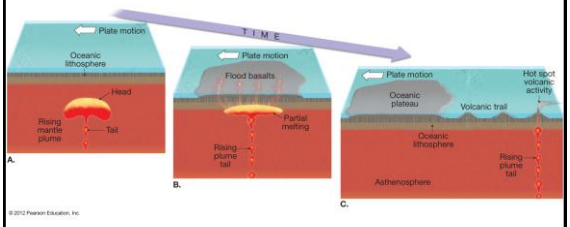


Figure 4.35

Global Volcanism

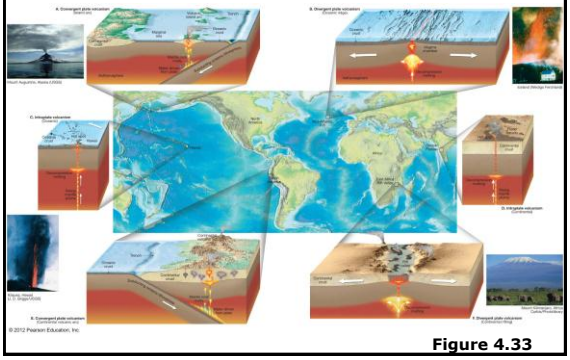


Figure 4.33

End of Chapter 4