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EARTH SCIENCE

Tarbuck Lutgens

Chapter 10

Volcanoes and Other Igneous Activity

10.1 The Nature of Volcanic Eruptions

Factors Affecting Eruptions

- Factors that determine the violence of an eruption
  - Composition of the magma
  - Temperature of the magma
  - Dissolved gases in the magma
- Viscosity
  - **Viscosity** is the measure of a material's resistance to flow.

10.1 The Nature of Volcanic Eruptions

Factors Affecting Eruptions

- Viscosity
  - Factors affecting viscosity
    - Temperature (hotter magmas are less viscous)
    - Composition (silica content)
      1. High silica—high viscosity (e.g., rhyolitic lava)
      2. Low silica—more fluid (e.g., basaltic lava)

10.1 The Nature of Volcanic Eruptions

Factors Affecting Eruptions

- Dissolved gases
  - Mainly water vapor and carbon dioxide
  - Gases expand near the surface
  - A **vent** is an opening in the surface of Earth through which molten rock and gases are released.
  - Provide the force to extrude lava

10.1 The Nature of Volcanic Eruptions

Factors Affecting Eruptions

- Dissolved gases
  - Violence of an eruption is related to how easily gases escape from magma
    - Gases escape easily from fluid magma.
    - Viscous magma produces a more violent eruption.

Magma Composition

Table 1 Magma Composition

Composition	Silica Content	Viscosity	Gas Content	Tendency to Form Pyroclastics (ejected rock fragments)	Volcanic Landform
Basaltic	Least (~50%)	Least	Least (1–2%)	Least	Shield Volcanoes Basalt Plateaus Cinder Cones
Andesitic	Intermediate (~60%)	Intermediate	Intermediate (3–4%)	Intermediate	Composite Cones
Rhyolitic	Most (~70%)	Greatest	Most (4–6%)	Greatest	Pyroclastic Flows Volcanic Domes

10.1 The Nature of Volcanic Eruptions

Volcanic Material

- Lava Flows
  - Basaltic lavas are more fluid.
  - Types of lava
    - Pahoehoe lava (resembles braids in ropes)
    - Aa lava (rough, jagged blocks)
- Gases
  - One to 5 percent of magma by weight
  - Mainly water vapor and carbon dioxide

Pahoehoe (Ropy) Lava Flow

Slow-Moving Aa Flow

10.1 The Nature of Volcanic Eruptions

Volcanic Material

- Pyroclastic Materials
  - **Pyroclastic materials** is the name given to particles produced in volcanic eruptions.
  - The fragments ejected during eruptions range in size from very fine duct and volcanic ash (less than 2 millimeters) to pieces that weigh several tons.

10.1 The Nature of Volcanic Eruptions

Volcanic Material

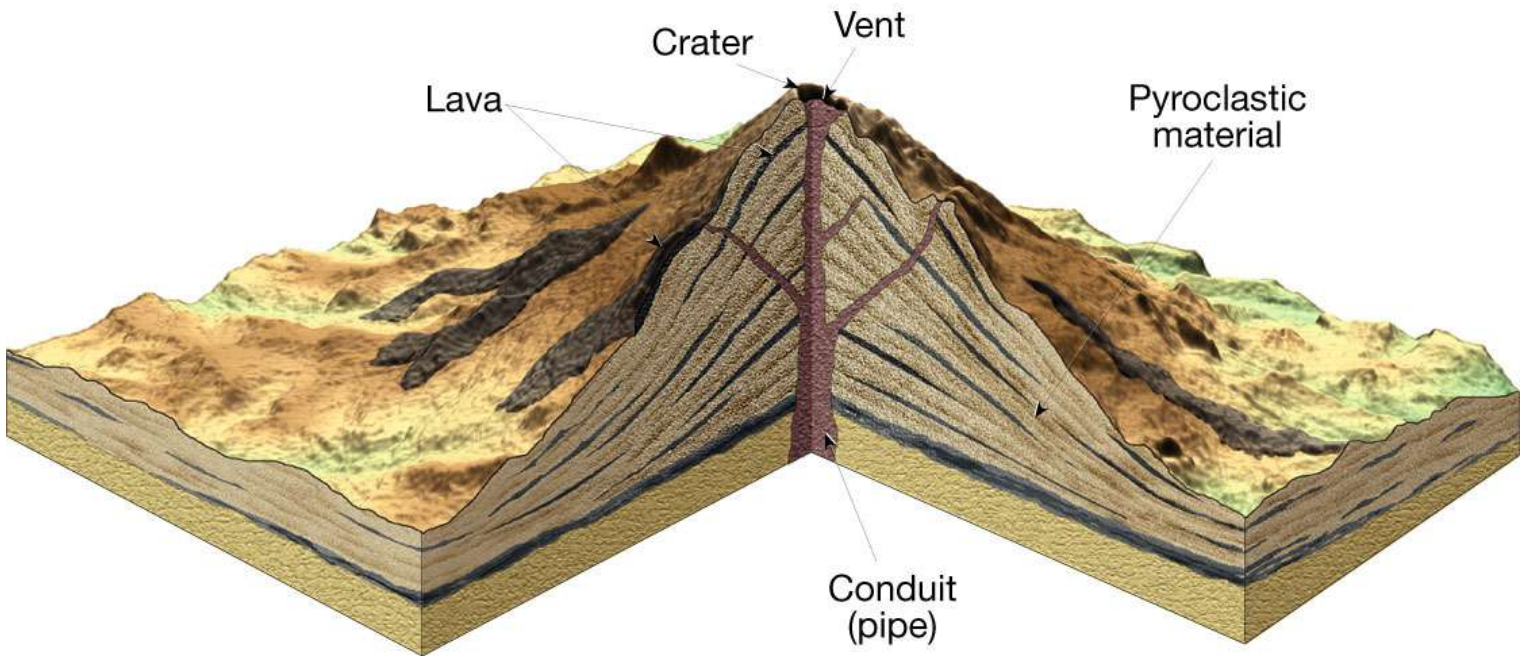
- Pyroclastic Materials
  - Types of pyroclastic material
    - Ash and dust—fine, glassy fragments
    - Pumice—frothy, air-filled lava
    - Lapilli—walnut-sized particles
    - Cinders—pea-sized particles
  - Particles larger than lapilli
    - Blocks—hardened lava
    - Bombs—ejected as hot lava

10.1 The Nature of Volcanic Eruptions

Types of Volcanoes

- The three main volcanic types are shield volcanoes, cinder cones, and composite cones.
- Anatomy of a Volcano
  - A **volcano** is a mountain formed of lava and/or pyroclastic material.
  - A **crater** is the depression at the summit of a volcano or that which is produced by a meteorite impact.
  - A conduit, or pipe, carries gas-rich magma to the surface.

Anatomy of a “Typical” Volcano

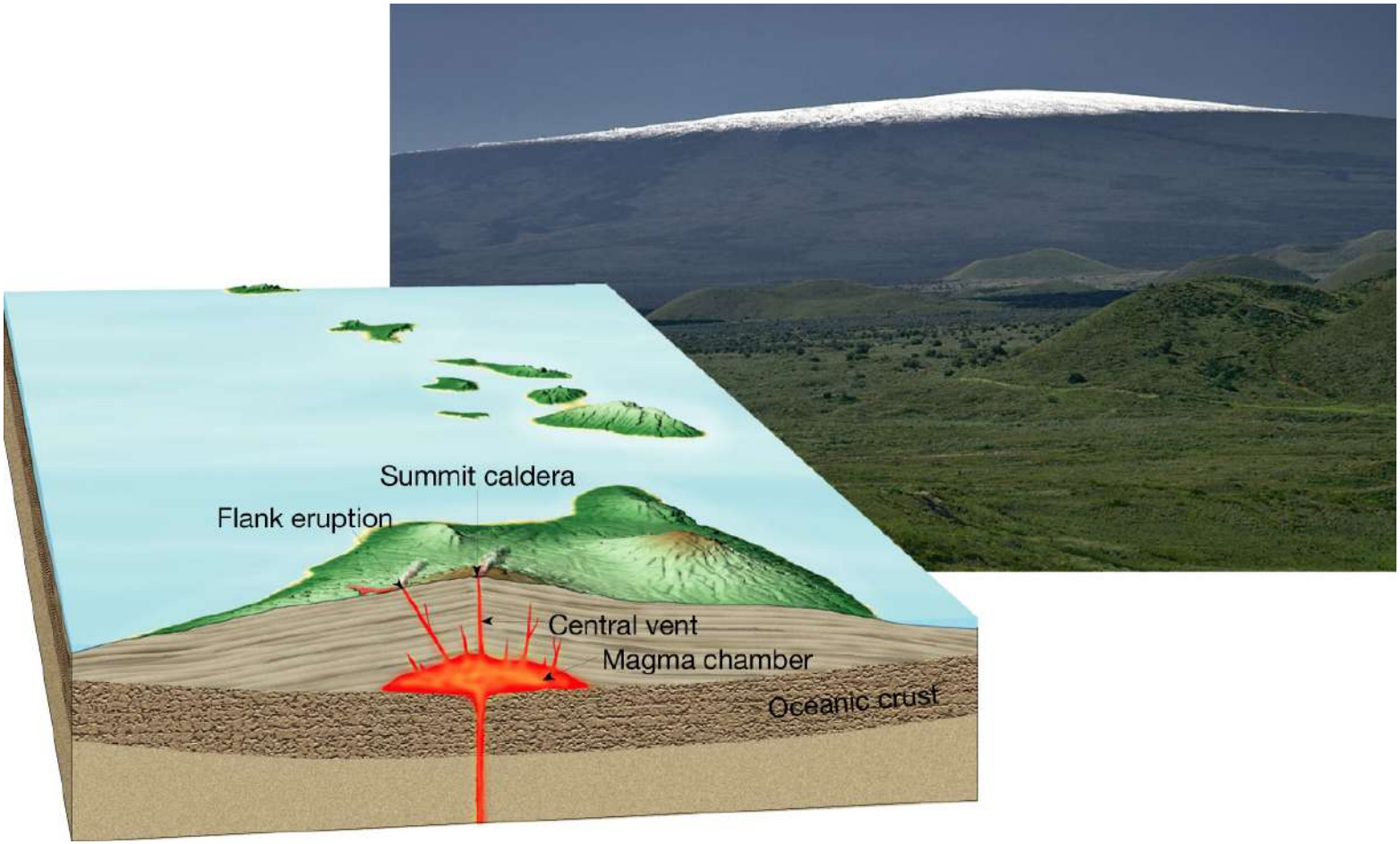


10.1 The Nature of Volcanic Eruptions

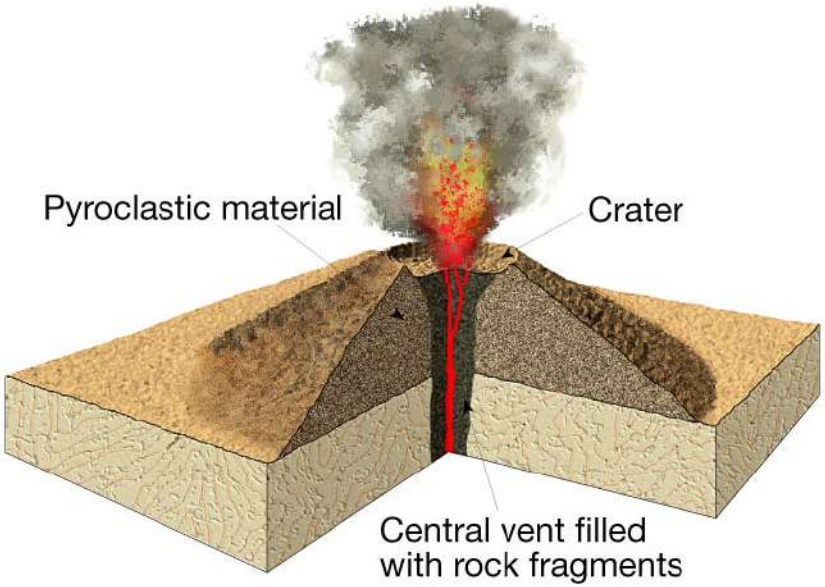
Types of Volcanoes

- Shield Volcanoes
  - **Shield volcanoes** are broad, gently sloping volcanoes built from fluid basaltic lavas.
- Cinder Cones
  - **Cinder cones** are small volcanoes built primarily of pyroclastic material ejected from a single vent.
    - Steep slope angle
    - Rather small in size
    - Frequently occur in groups

Shield Volcanoes



Cinder Cones



10.1 The Nature of Volcanic Eruptions

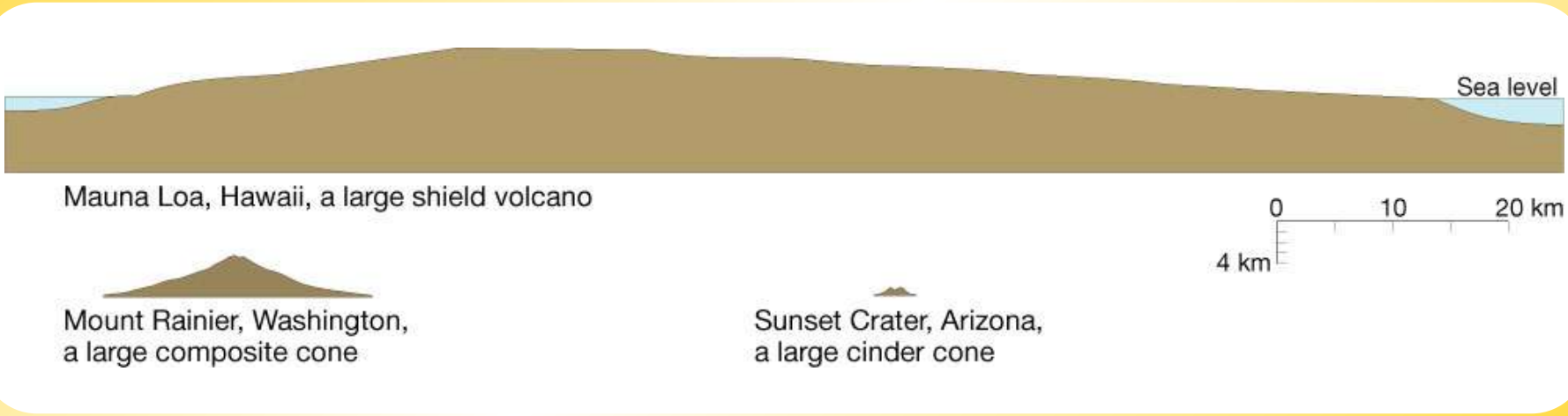
Types of Volcanoes

- Composite Cones
  - **Composite cones** are volcanoes composed of both lava flows and pyroclastic material.
    - Most are adjacent to the Pacific Ocean (e.g., Mt. Rainier).
    - Large size
    - Interbedded lavas and pyroclastics
    - Most violent type of activity

Composite Cones

Mount St. Helens Before and After the May 18, 1980, Eruption

Profiles of Volcanic Landforms



10.1 The Nature of Volcanic Eruptions

Other Volcanic Landforms

- Calderas
  - **Calderas** are large depressions in volcanoes.
  - Nearly circular
  - Formed by collapse
  - Size exceeds one kilometer in diameter

10.1 The Nature of Volcanic Eruptions

Other Volcanic Landforms

- Lava Plateaus
  - Fluid basaltic lava extruded from crustal fractures called fissures.

10.2 Intrusive Igneous Activity

Plutons

- **Plutons** are intrusive igneous structures that result from the cooling and hardening of magma beneath the surface of Earth.
  - Intrusive igneous bodies, or plutons, are generally classified according to their shape, size, and relationship to the surrounding rock layers.

10.2 Intrusive Igneous Activity

Plutons

- Sills and Laccoliths
  - Sills and laccoliths are plutons that form when magma is intruded close to the surface.
    - **Sills** resemble buried lava flows and may exhibit columnar joints.
    - **Laccoliths** are lens-shaped masses that arch overlying strata upward.

Sills

10.2 Intrusive Igneous Activity

Plutons

- Dikes
  - **Dikes** are tabular-shaped intrusive igneous features that cut across preexisting rock layers.
  - Many dikes form when magma from a large magma chamber invades fractures in the surrounding rocks.

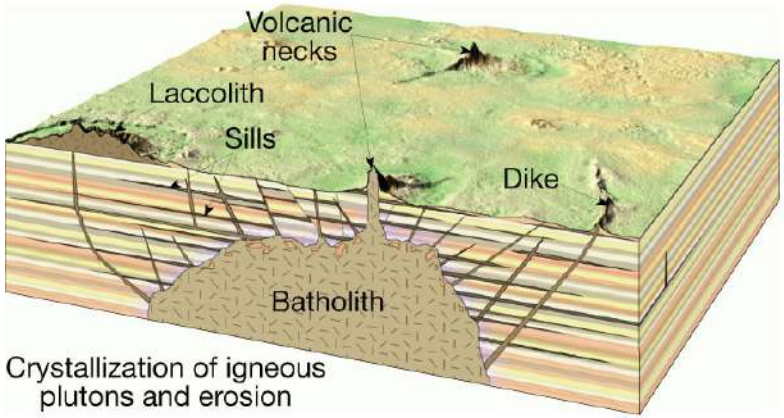
10.2 Intrusive Igneous Activity

Plutons

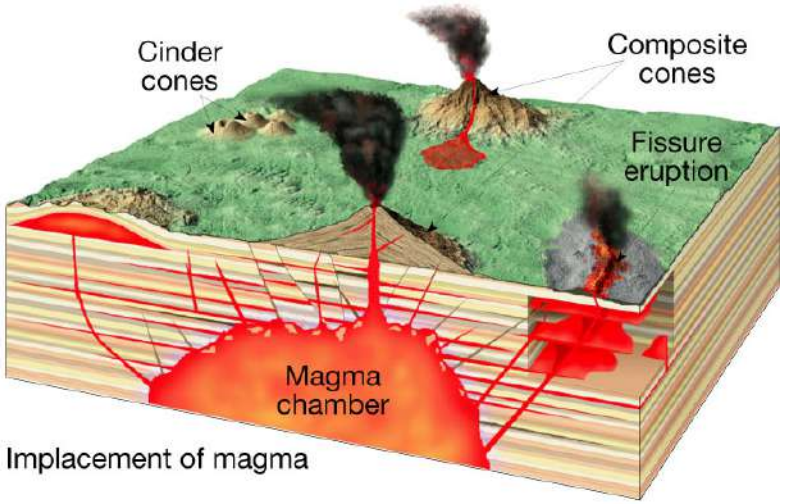
- Batholiths
  - **Batholiths** are large masses of igneous rock that formed when magma intruded at depth, became crystallized, and subsequently was exposed by erosion.
  - An intrusive igneous body must have a surface exposure greater than 100 square kilometers to be considered a batholith.

Batholiths

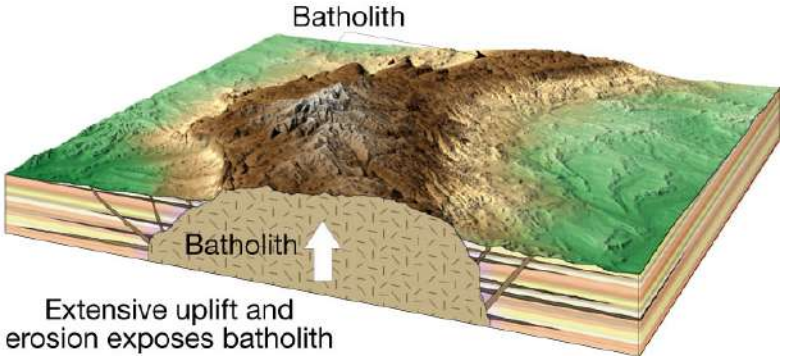
Types of Igneous Plutons



Crystallization of igneous plutons and erosion



Implacement of magma



Extensive uplift and erosion exposes batholith

10.2 Intrusive Igneous Activity

Origin of Magma

- Geologists conclude that magma originates when essentially solid rock, located in the crust and upper mantle, partially melts.

- The most obvious way to generate magma from solid rock is to raise the temperature above the level at which the rock begins to melt.

10.2 Intrusive Igneous Activity

Origin of Magma

- Role of Heat
  - The **geothermal gradient**—Earth's natural temperature increases with depth but is not sufficient to melt rock in the lower crust and upper mantle
  - Additional heat is generated by
    - friction in subduction zones
    - crustal rocks heated during subduction
    - rising, hot mantle rocks

10.2 Intrusive Igneous Activity

Origin of Magma

- Role of Water
  - Causes rock to melt at a lower temperature
  - Plays an important role in subducting ocean plates

10.3 Plate Tectonics and Igneous Activity

Convergent Plate Boundaries

- The basic connection between plate tectonics and volcanism is that plate motions provide the mechanisms by which mantle rocks melt to generate magma.
- Ocean-Ocean
  - Rising magma can form volcanic island arcs in an ocean (Aleutian Islands).
- Ocean-Continent
  - Rising magma can form continental volcanic arcs (Andes Mountains).

Divergent Plate Boundaries

- The greatest volume of volcanic rock is produced along the oceanic ridge system.
  - Lithosphere pulls apart.
  - Less pressure on underlying rocks
  - Partial melting occurs
  - Large quantities of fluid basaltic magma are produced.

Intraplate Igneous Activity

- **Intraplate volcanism** is igneous activity that occurs within a tectonic plate away from plate boundaries.
  - Most intraplate volcanism occurs where a mass of hotter than normal mantle material called a mantle plume rises toward the surface.
  - The activity forms localized volcanic regions called hot spots.
  - Examples include the Hawaiian Islands and the Columbia Plateau.