

# 4 Volcanoes & Other Igneous

## Activity

### I. Volcanic eruptions

#### A. Factors that determine the violence of an eruption

1. Composition of the magma
2. Temperature of the magma
3. Dissolved gases in the magma

#### B. **Viscosity** of magma

1. Viscosity is a measure of a material's resistance to flow
2. Factors affecting viscosity
  - a. Temperature (hotter magmas are less viscous)
  - b. Composition (silica content)
    1. High silica = high viscosity (e.g. felsic lava)
    2. Low silica = more fluid (e.g., mafic lava)
- c. Dissolved gases
  1. Gas content affects magma mobility
  2. Gases expand near the surface and extrude lava
  3. Violence of an eruption is related to how easily gases escape from magma
    - a. Fluid basaltic lavas are generally quiescent
    - b. Highly viscous magmas produce explosive eruptions



### II. Materials extruded during an eruption

#### A. Lava flows

1. Basaltic lavas are more fluid
2. Types of basaltic lava
  - a. **Pahoehoe** lava (resembles braids in ropes)
  - b. **Aa** lava (rough, jagged blocks)

#### B. Gases

1. One to 6 percent of magma by weight
2. Mainly water vapor, carbon dioxide, nitrogen, sulfur dioxide

#### C. Pyroclastic materials

1. "Fire fragments"
2. Types of pyroclastic material
  - a. Ash and dust - fine, glassy fragments
  - b. Pumice - from "frothy" lava
  - c. **Lapilli** - "walnut" size
  - d. **Cinders** - "pea-sized"

- e. Particles larger than lapilli
  - 1. **Blocks** - hardened lava
  - 2. **Bombs** - ejected as hot lava (often streamlined in shape)
- D. Temperatures of volcanic materials are typically around 1,000°C

### III. Volcanoes

#### A. General features

- 1. Opening at summit
  - a. **Crater** (steep-walled depression at the summit)
  - b. **Caldera** (a summit depression greater than 1 km diameter)
- 2. **Vent** (connected to the magma chamber via a pipe)

#### B. Types of volcanoes

##### 1. **Shield volcano**

- a. Broad, slightly domed
- b. Primarily made of basaltic (fluid) lava
- c. Generally large
- d. Generally produce a large volume of lava
- e. e.g. Mauna Loa and Kilauea in Hawaii
- f. eruptions are usually preceded by months of inflation of the summit with magma, followed by a swarm of small earthquakes (< 24 Hrs. before)

##### 2. **Cinder cone**

- a. Built from pyroclastics
- b. Steep slope angle
- c. Rather small size (often < 300m high)
- d. Frequently occur in groups
- e. e.g. Flagstaff, Arizona and Paricutin, Mexico

##### 3. **Composite cone** (or stratovolcano)

- a. Most are adjacent to the Pacific Ocean (e.g., Fujiyama, Vesuvius, Mt. Shasta)
- b. Large size
- c. Interbedded lavas and pyroclastics
- d. Most violent type of activity (e.g. Vesuvius)
- e. Often produce **nuée ardente**
  - 1. Fiery pyroclastic flow made of hot gases infused with ash
  - 2. Flows down sides of a volcano at speeds up to 200 km per hour
- f. May produce a **lahar**, a type of volcanic mudflow
- g. e.g. Ring of Fire, Andes, Cascade Range (U.S.)
- h. In late stages, a bulbous mass of viscous lava called a **lava dome** builds up above the vent
- i. Mount St. Helens eruption of May, 1980
  - 1. eruption was preceded by the growth of a large magmatic bulge on the north flank
  - 2. the collapse of the north flank was the largest landslide in recorded history
  - 3. the rapid reduction in pressure unleashed a large lateral (sideways) eruption

4. about 1 cubic km. of rock was ejected
5. resulting crater is 1 mile wide
6. the lateral eruption produced a large pyroclastic flow to the north
7. lahars flooded Spirit Lake and the Toutle River Valley
8. volcanic ash reached 18 km in height and formed thick deposits to the east.

#### IV. Other volcanic landforms

##### A. **Calderas**

1. Steep walled depression at the summit
2. Size exceeds one kilometer in diameter
3. Types of calderas
  - a. Crater Lake-type – produced by a single explosive eruption of a large composite volcano, followed by collapse of the summit
  - b. Hawaiian-type – gradual subsidence of the summit as magma drains through rift zones
  - c. Yellowstone-type – colossal eruptions and extensive pyroclastic flows – largest volcanic structures on Earth (e.g. Valles and Long Valley Calderas)

##### B. **Fissure eruptions and lava plateaus**

1. Fluid basaltic lava extruded from crustal fractures called **fissures**
2. Produces **flood basalts** (e.g., Columbia Plateau)

##### C. Volcanic pipes and necks

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

#### V. Intrusive igneous activity (see Lab Manual p. 77, Fig. 5.1)

##### A. Most magma is emplaced at depth

##### B. An underground igneous body is called a **pluton**

##### C. Plutons are classified according to

1. Shape
  - a. **Tabular** (sheet-like)
  - b. **Massive**
2. Orientation with respect to the host (surrounding) rock
  - a. **Discordant** - cuts across sedimentary beds
  - b. **Concordant** - parallel to sedimentary beds

##### D. Types of igneous intrusive features

1. **Dike**, a tabular, discordant pluton
2. **Sill**, a tabular, concordant pluton (e.g., Palisades Sill, NY)
3. **Laccolith**
  - a. Similar to a sill
  - b. Lens shaped mass
  - c. Arches overlying strata upward

#### 4. Batholith

- a. Largest intrusive body
- b. Surface exposure 100+ square kilometers (smaller bodies are termed stocks)
- c. Frequently form the cores of mountains
- d. e.g. Yosemite, CA; White Mts., NH; Acadia, ME

#### VI. Plate tectonics and igneous activity

- A. Global distribution of igneous activity is not random
  1. Most volcanoes are located along plate boundaries at the margins of ocean basins
  2. Other general locations include
    - a. Deep ocean basins
    - b. Interiors of the continents ("intraplate")
  3. Plate motions provide the mechanism by which mantle rocks melt to generate magma
  4. the **geothermal gradient** averages about 20°C – 30°C per kilometer of depth, and plays a role in the origin and evolution of magma
- B. Igneous activity at convergent plate boundaries
  1. Oceanic crust descends into the mantle, generating an oceanic trench
  2. Descending plate partially melts
  3. Magma slowly rises upward through denser rock
  4. Rising magma can form
    - a. **Volcanic island arc** in an ocean
    - b. Andesitic to granitic volcanoes in a **continental volcanic arc**
  5. Most of the activity is associated with the rim of the Pacific Basin, called the "**Ring of Fire**"
- C. Igneous activity at divergent plate boundaries
  1. The greatest volume of magma is produced along the oceanic ridge system
    - a. Lithosphere pulls apart
    - b. Less confining pressure on underlying rocks
    - c. Partial melting of mantle peridotite rock results from decompression melting
    - d. Large quantities of basaltic magma are produced
  2. Not all spreading centers are located along the axis of an oceanic ridge
- D. **Intraplate** igneous activity
  1. Activity within a rigid plate
  2. Plumes of hot, less dense mantle material ascend toward the surface
    - a. Form localized volcanic regions called **hot spots**
    - b. Associated with the Hawaiian Islands and Yellowstone