



ECIV 3302
Engineering Geology

Chapter 4

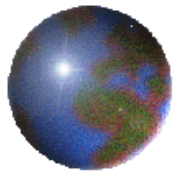
VOLCANOES & VOLCANIC HAZARDS

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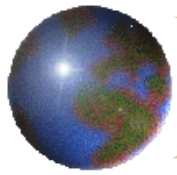
Islamic University of Gaza, Palestine

The materials are mostly adapted from the presentation of Stan & Cindy Hatfield



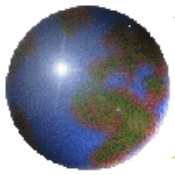
The Nature of Volcanic Eruptions

- ✚ Factors determining the “violence” or explosiveness of a volcanic eruption:
 - **Temperature** of the magma
 - **Composition** of the magma
 - **Dissolved gases** in the magma
- ✚ The above three factors actually 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.
- ✚ Factors affecting viscosity:
 1. **Temperature** - Hotter magmas are less viscous
 2. **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

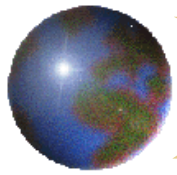
✚ Factors affecting viscosity continued

3. 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

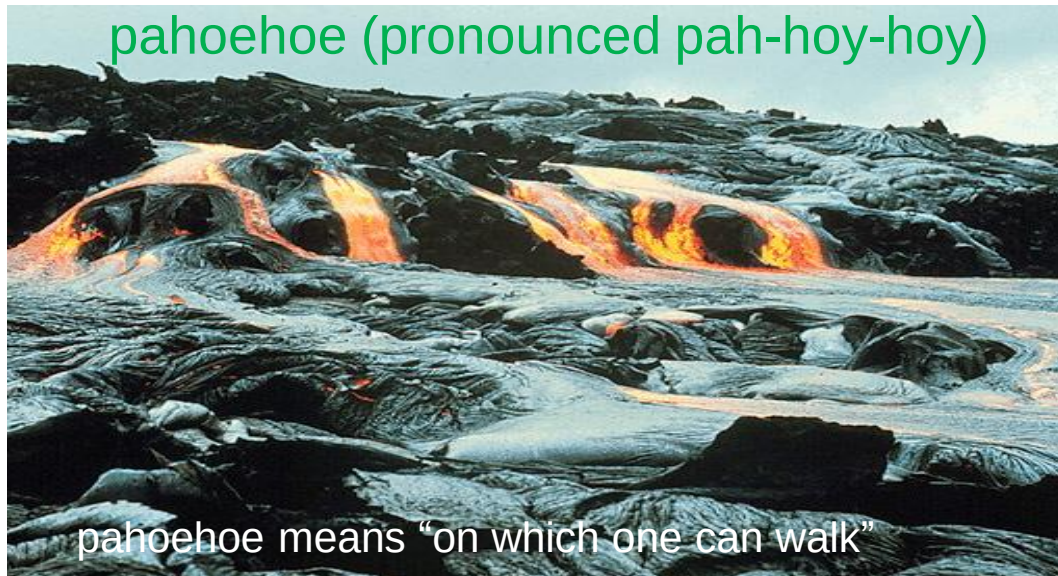
- Fluid basaltic lavas generally produce quiet eruptions
- Highly viscous lavas (rhyolite or andesite) produce more explosive eruptions



Materials extruded from a volcano

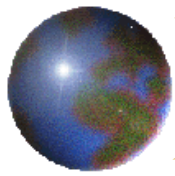
✚ Lava Flows

- Basaltic lavas are much more fluid
- Types of basaltic flows:
 - **Pahoehoe** lava (resembles a twisted or ropey texture)
 - **Aa** lava (rough, jagged blocky texture)



A Pahoehoe lava flow



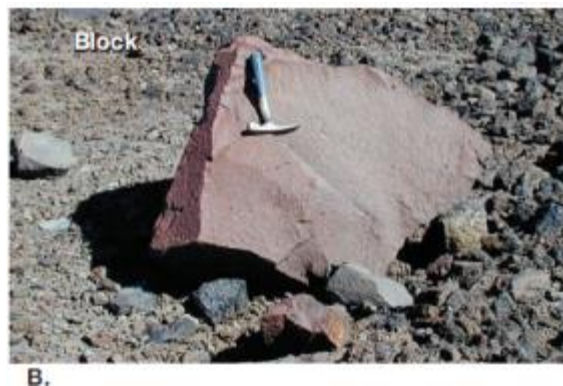
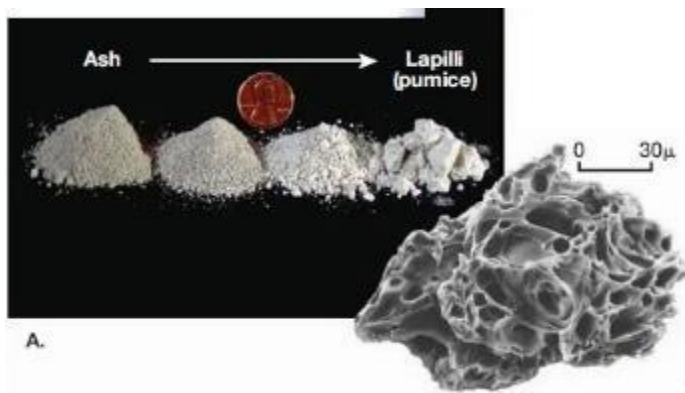
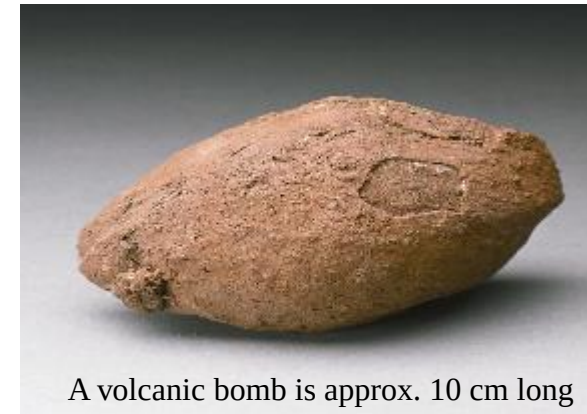


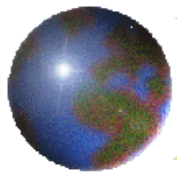
Materials extruded from a volcano

✚ Pyroclastic materials – “Fire fragments”

Types of pyroclastic debris

- **Ash and dust** - fine, glassy fragments
- **Pumice** - porous rock from “frothy” lava
- **Lapilli** - walnut-sized material
- **Cinders** - pea-sized material
- Particles larger than lapilli
 - **Blocks** - hardened or cooled lava
 - **Bombs** - ejected as hot lava





Volcanic structures & eruptive styles

General Features

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

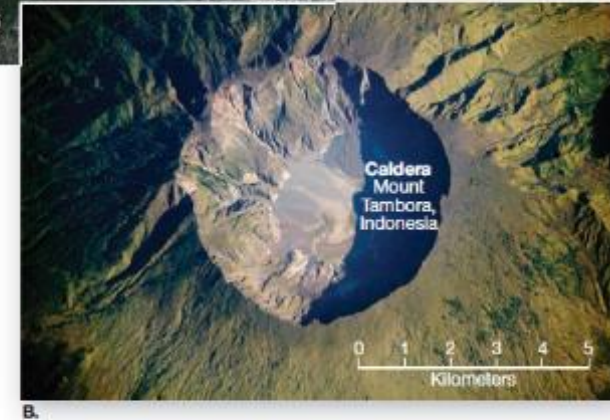
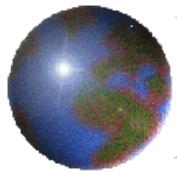


FIGURE 4.12 Crater versus caldera. **A.** The crater of Mount Vesuvius, Italy, is about 0.5 kilometer in diameter. The city of Naples is located northwest of Vesuvius, whereas Pompeii, the Roman town that was buried by an eruption in AD 79, is located southeast of the volcano. **B.** The huge caldera—6 kilometers in diameter—formed when Tambora's peak was removed during an explosive eruption in 1815. (Photos courtesy of NASA)

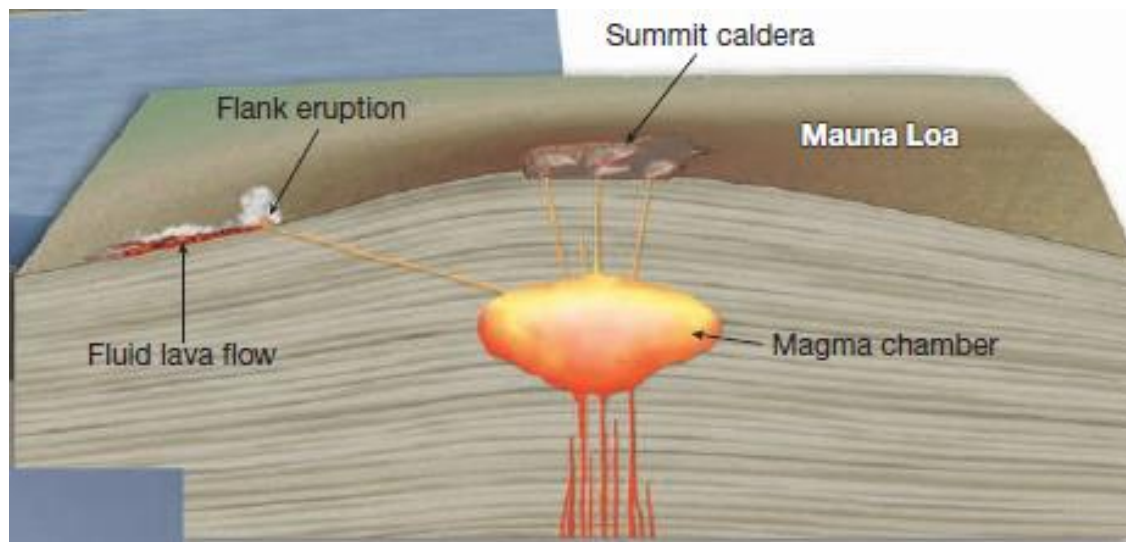


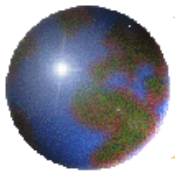
Volcanic structures & eruptive styles

✚ Types of volcanoes

1. Shield volcano

- Broad, slightly domed-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



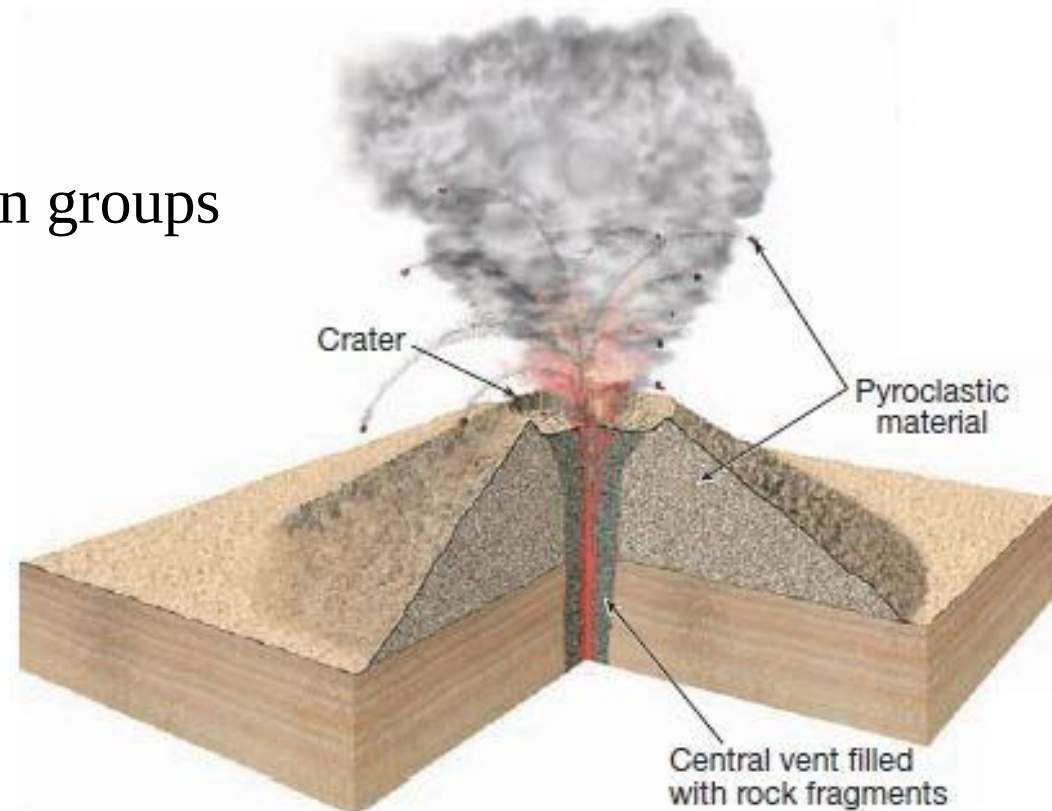


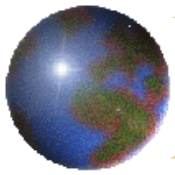
Volcanic structures & eruptive styles

✚ Types of volcanoes cont'd

2. Cinder cone

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



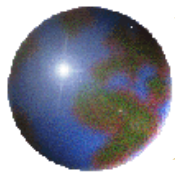


Volcanic structures & eruptive styles

✚ Types of volcanoes cont'd

3. 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 & several miles wide at base)
- Composed of interbedded lava flows and layers of pyroclastic debris



Volcanic structures & eruptive styles

A composite volcano

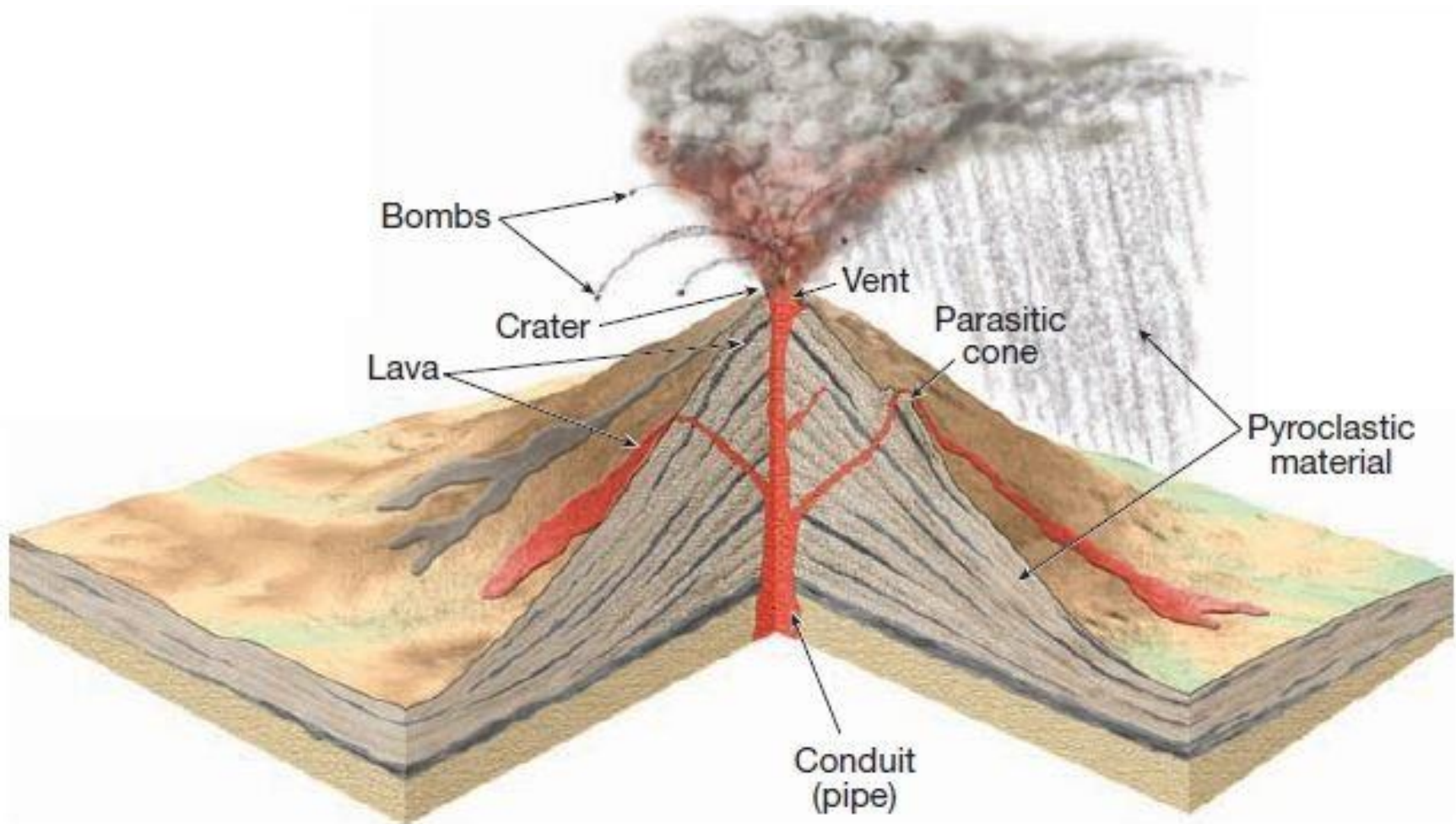
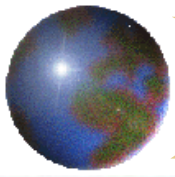
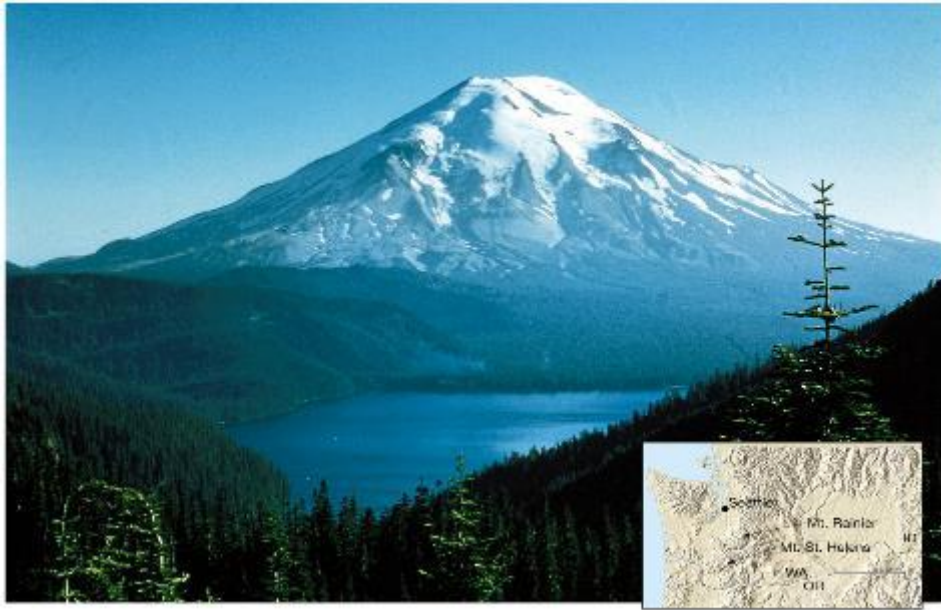


FIGURE 4.11 Anatomy of a “typical” composite cone (see also Figures 4.13 and 4.16 for a comparison with a shield and cinder cone, respectively).



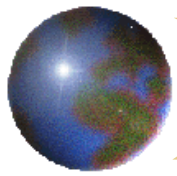
Volcanic structures & eruptive styles



Mt. St. Helens – a typical composite volcano

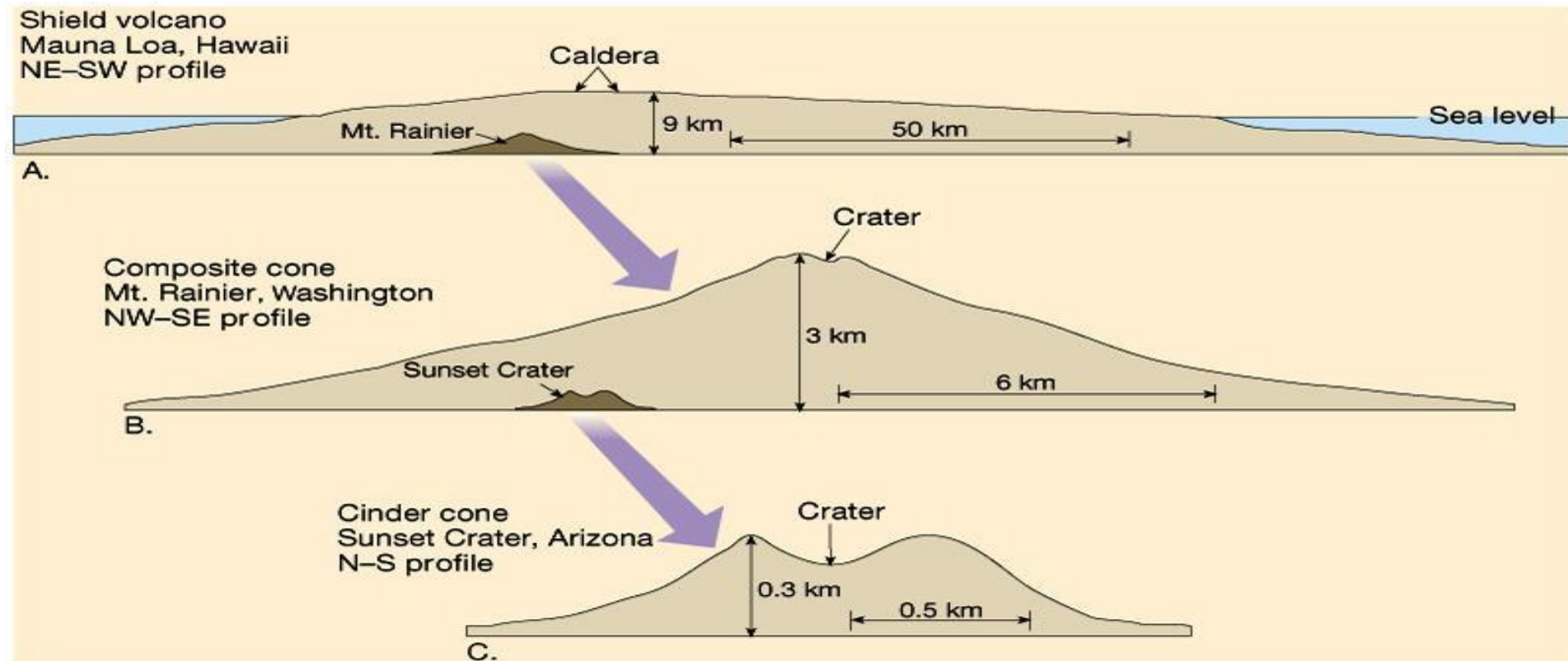
Mt. St. Helens
following the 1980
eruption

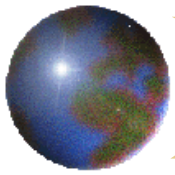




Volcanic structures & eruptive styles

A size comparison of the three types of volcanoes





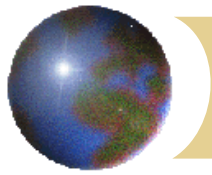
Volcanic structures & eruptive styles

3. Composite cones cont'd

- Most violent type of activity (e.g., Mt. Vesuvius)
- Often produce a **nueé ardente**
 - 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 nueé ardente on Mt. St. Helens



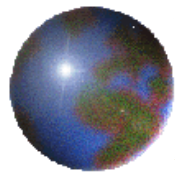
Other volcanic landforms

✚ Calderas

- Steep-walled depressions at the summit
- Size generally exceeds 1 km in diameter

✚ Pyroclastic flows

- Associated with felsic & intermediate magma
- Consists of ash, pumice, and other fragmental debris
- Material is propelled from the vent at a high speed
- e.g., Yellowstone plateau



Other volcanic landforms

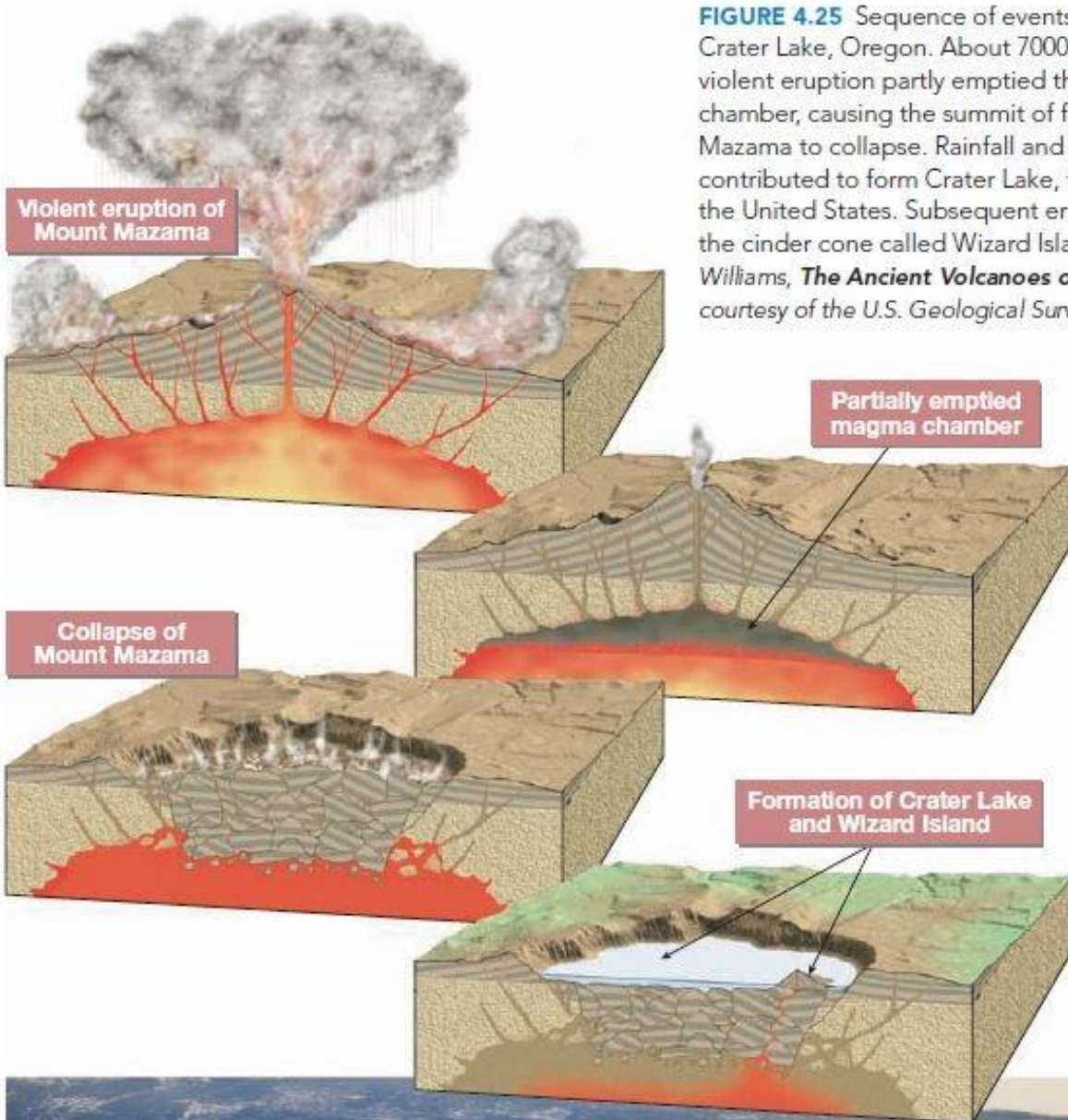
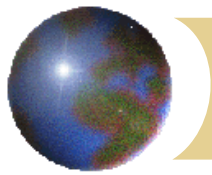


FIGURE 4.25 Sequence of events that formed Crater Lake, Oregon. About 7000 years ago a violent eruption partly emptied the magma chamber, causing the summit of former Mount Mazama to collapse. Rainfall and groundwater contributed to form Crater Lake, the deepest lake in the United States. Subsequent eruptions produced the cinder cone called Wizard Island. (After H. Williams, *The Ancient Volcanoes of Oregon*. Photo courtesy of the U.S. Geological Survey)

Caldera





Other volcanic landforms

✚ Fissure eruptions and lava plateaus

- Fluid basaltic lava extruded from crustal fractures called fissures
- e.g., Columbia River Plateau

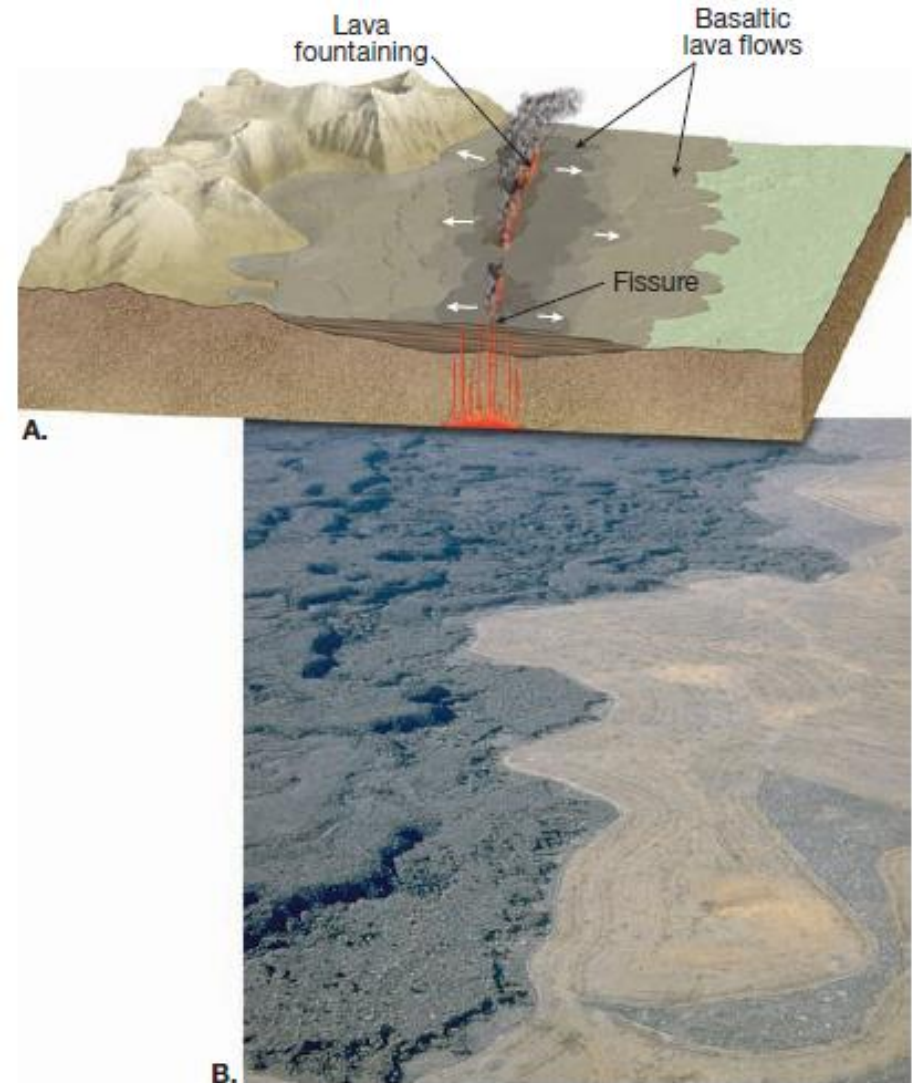
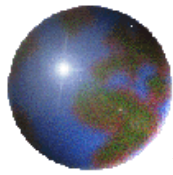


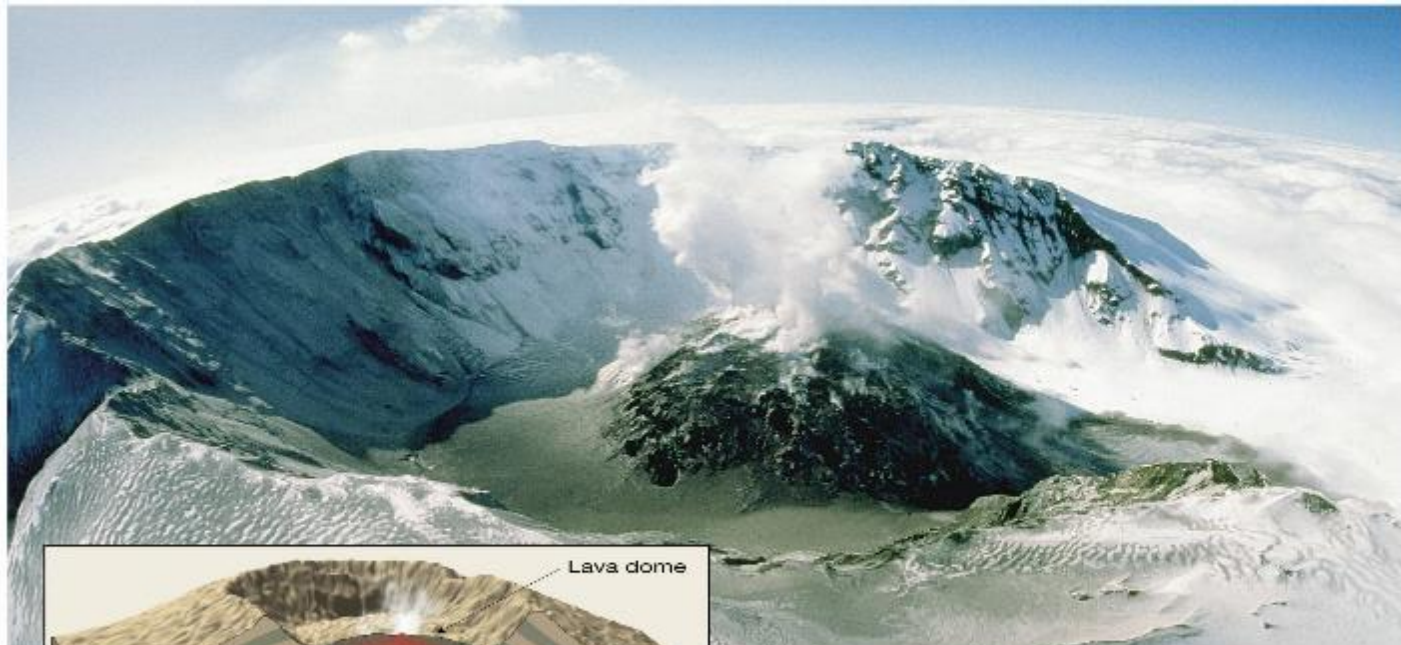
FIGURE 4.27 Basaltic fissure eruption. **A.** Lava fountaining from a fissure and formation of fluid lava flows called flood basalts. **B.** Photo of basalt flows near Idaho Falls. (Photo by John S. Shelton)



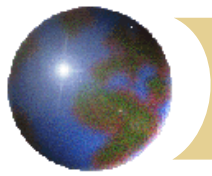
Other volcanic landforms

✚ Lava Domes

- Bulbous mass of congealed lava
- Most are associated with explosive eruptions of gas-rich magma



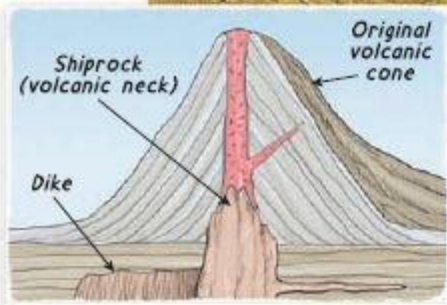
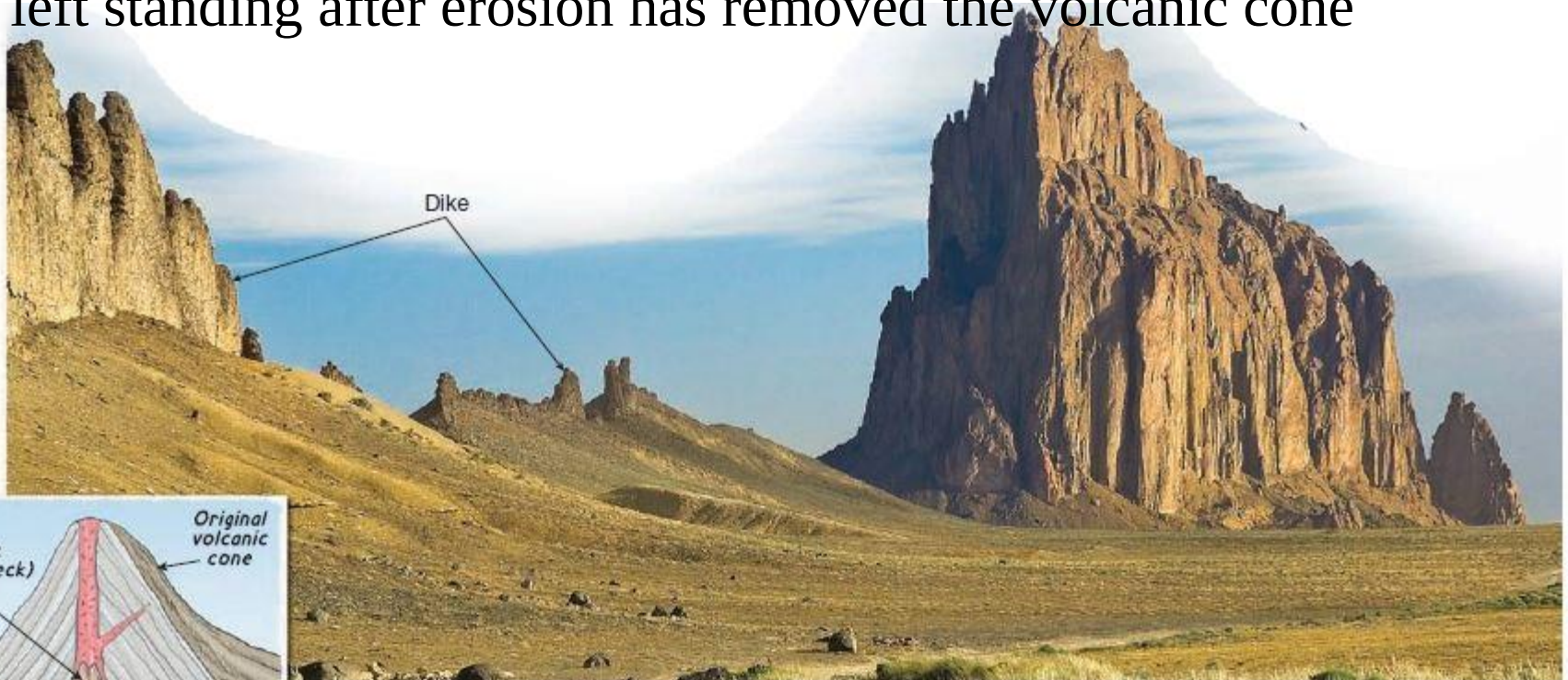
A lava dome on Mt. St. Helens



Other volcanic landforms

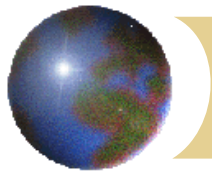
✚ Volcanic pipes and necks

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



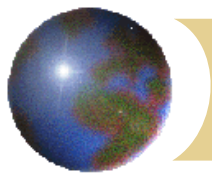
Geologist's Sketch

FIGURE 4.31 Shiprock, New Mexico, is a volcanic neck. This structure, which stands over 420 meters (1380 feet) high, consists of igneous rock that crystallized in the vent of a volcano that has long since been eroded away. (Photo by Dennis Tasa)



Plutonic igneous activity

- ✚ Most magma is emplaced at depth in the Earth
 - An underground igneous body, once cooled and solidified, is called a **pluton**
- ✚ Classification of plutons
 - Shape
 - Tabular (sheet-like)
 - Massive



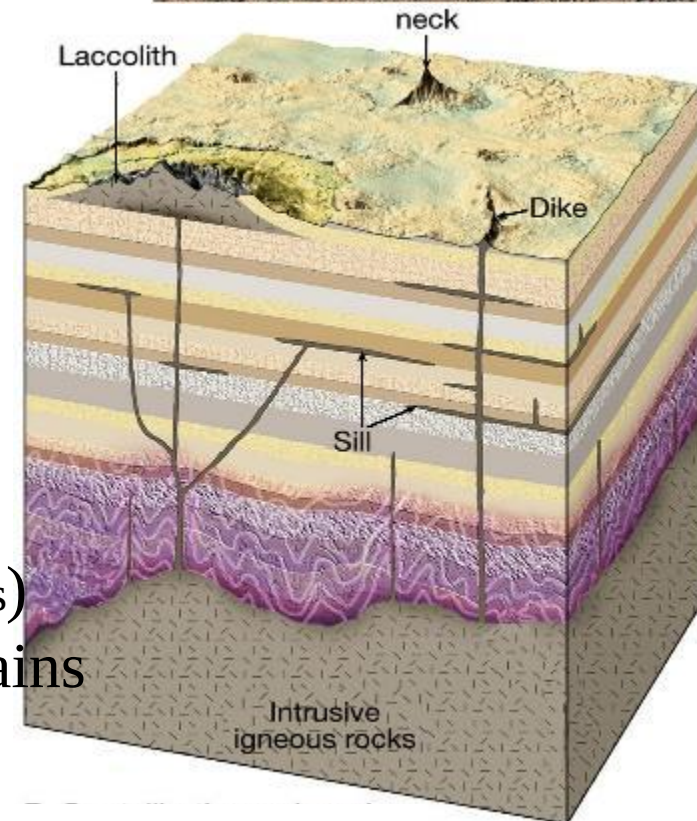
Plutonic igneous activity

✚ Types of intrusive igneous features

1. **Dike** – a tabular, discordant pluton
2. **Sill** – a tabular, concordant pluton (e.g., Palisades Sill in New York)
3. **Laccolith**
 - Similar to a sill
 - Lens or mushroom-shaped mass
 - Arches overlying strata upward
4. **Batholith**
 - Largest intrusive body
 - Surface exposure of +100 square kilometers (smaller bodies are termed stocks)
 - Frequently form the cores of mountains



A sill in the Salt River Canyon, Arizona



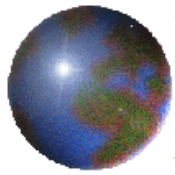


Plate tectonics and igneous activity

- ✚ 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

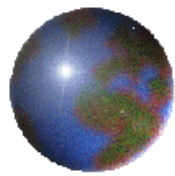


Plate tectonics and igneous activity

Distribution of some of the world's major volcanoes

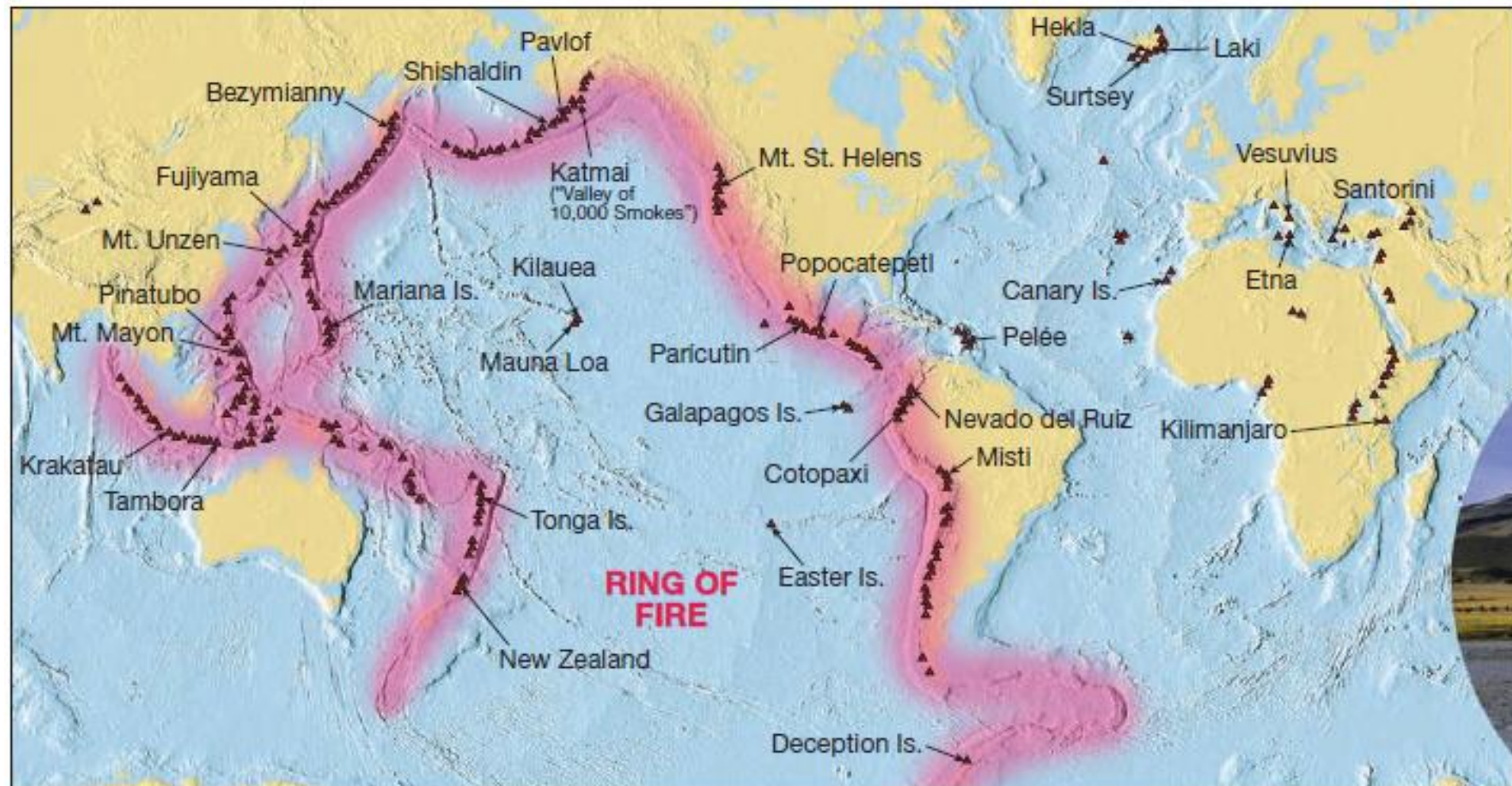


FIGURE 4.32 Locations of some of Earth's major volcanoes. (Photo by Patrick Escudero/Photolibrary)

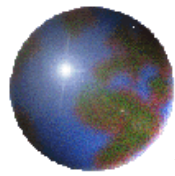
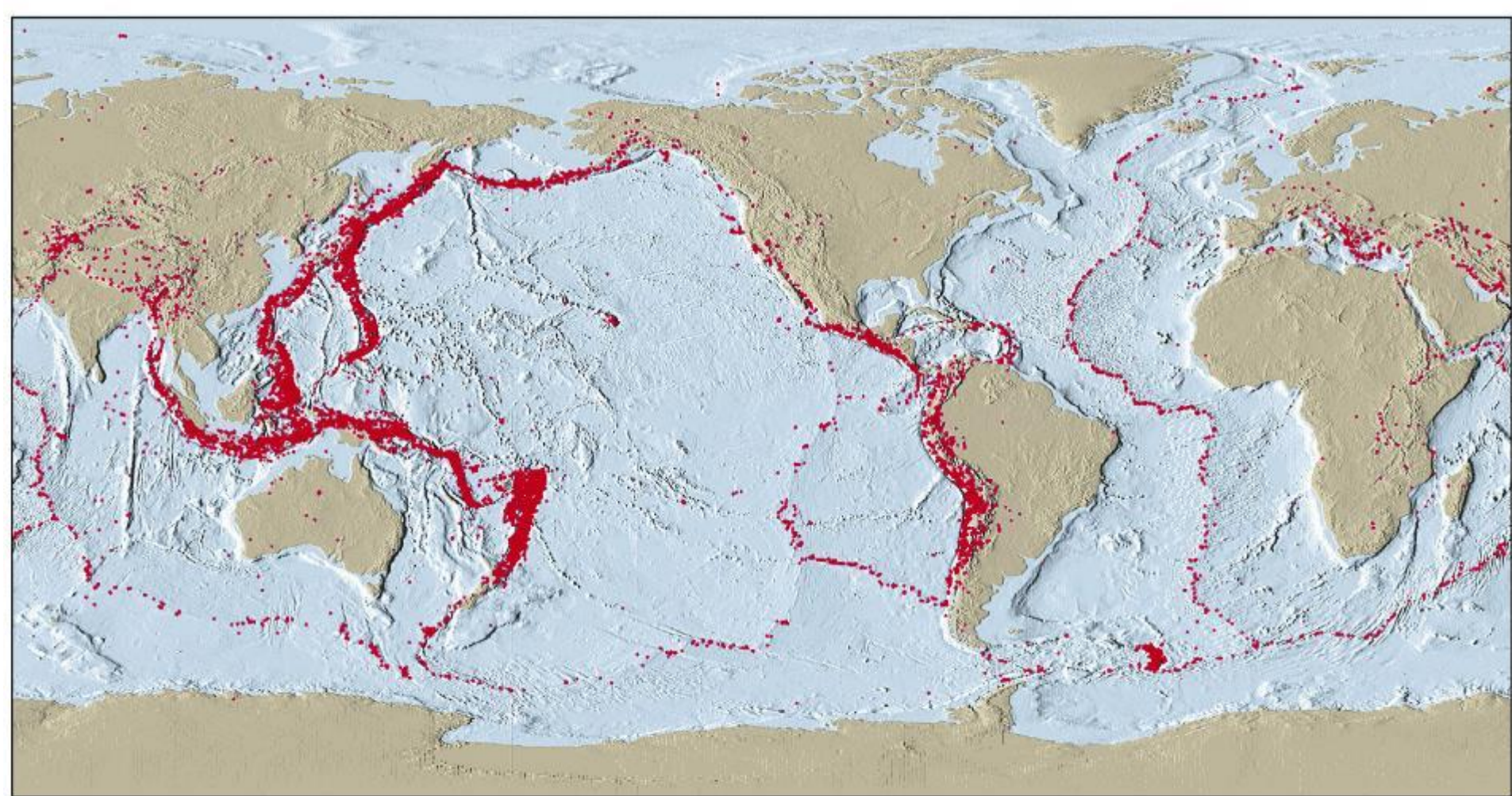


Plate tectonics and igneous activity

Distribution of magnitude 5 or greater earthquakes, 1980 - 1990



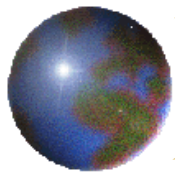
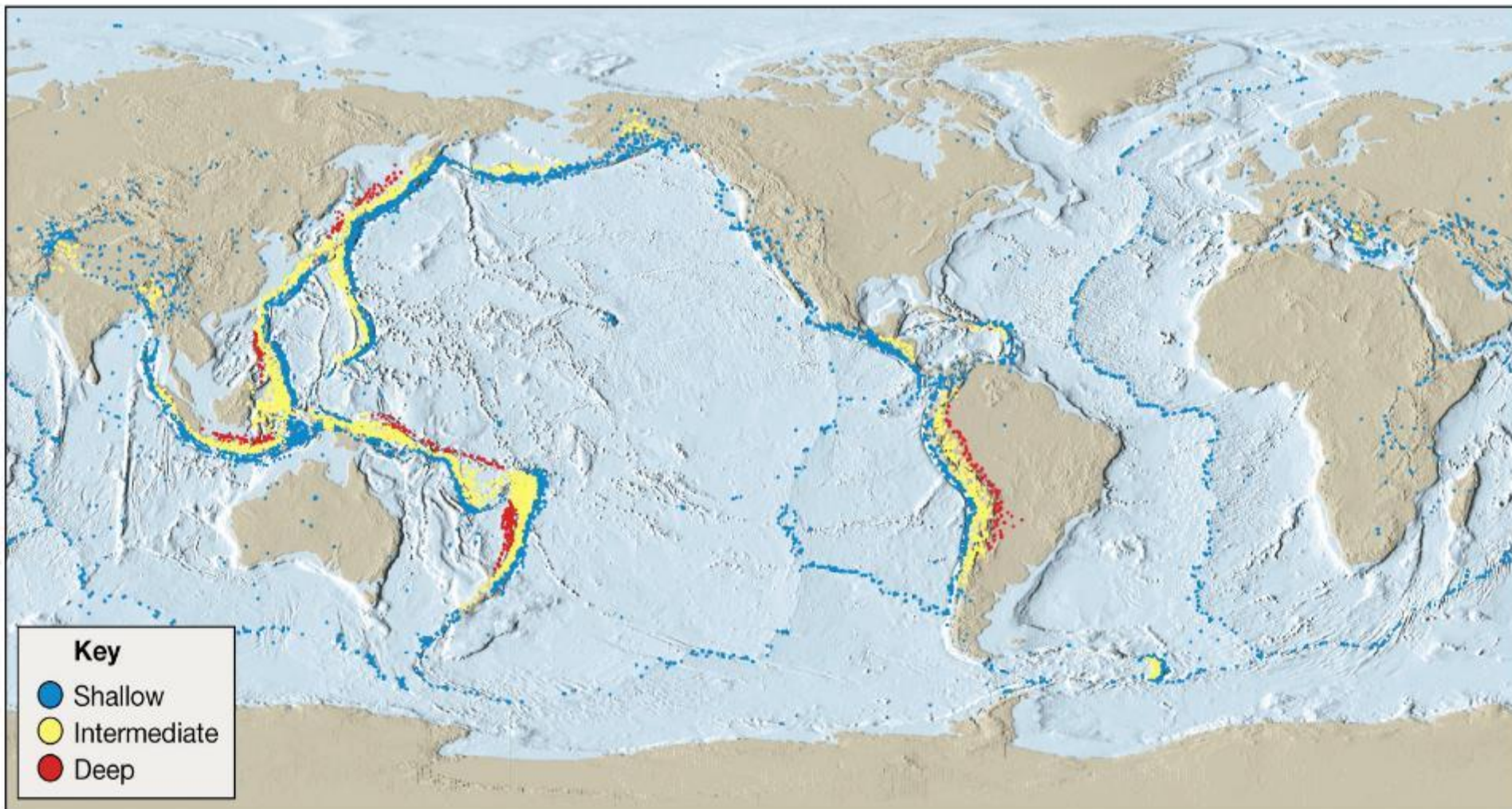
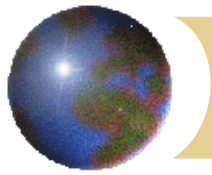


Plate tectonics and igneous activity

Deep-focus earthquakes occur along convergent boundaries





Volcanoes and climate

- ✚ Explosive eruptions emit huge quantities of gases and fine-grained debris into the atmosphere, which filter out and reflect a portion of the incoming solar radiation
- ✚ Examples of volcanism affecting climate
 - Mount Tambora, Indonesia – 1815
 - Krakatau, Indonesia – 1883
 - Mount Pinatubo, Philippines - 1991