

1  **Volcanoes & Other Igneous Activity**

2  **Volcanoes: summary in haiku form**

A volcano forms.

Magma comes to the surface -  
explodes, if felsic.

3 

4 

5 

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

7  **The Nature of Volcanic Eruptions**

- All eruptions involve magma
  - Magma is molten rock that usually contains some crystals and varying amounts of dissolved gases
  - Lava is erupted magma
- The behavior of magma is determined by:
  - Temperature of the magma
  - Composition of the magma
  - Dissolved gases in the magma
- The above three factors control the viscosity of a magma, which in turn controls the nature of an eruption
  -

8  **The Nature of Volcanic Eruptions**

- Viscosity is a measure of a material's resistance to flow
  - The more viscous the material, the greater its resistance to flow
  - Ex: syrup is more viscous than water
- Factors affecting viscosity
  - Temperature – hotter magmas are less viscous
  - Composition – silica (SiO<sub>2</sub>) content
    - Higher silica content magmas are more viscous (e.g., rhyolitic and andesitic magmas)
    - Lower silica content magmas are less viscous (e.g., basaltic lavas)
    - Silicate structures (tetrahedra) start to link together in long chains early in the crystallization process.

9  **The Nature of Volcanic Eruptions**

- Factors affecting viscosity (*continued*)
  - Dissolved gases
    - Dissolved water in magma reduces viscosity
    - Gases expand within a magma as it nears Earth's surface due to decreasing pressure
    - The violence of an eruption is related to how easily gases escape from magma

10  **The Nature of Volcanic Eruptions**

- Quiescent Versus Explosive Eruptions

11  **Materials Extruded During an Eruption**

- Lava
  - Lava Flows
    - ~90 percent of lava is basaltic lava
    - <10 percent of lava is andesitic lava
    - ~1 percent of lava is rhyolitic lava
  - Aa and Pahoehoe Flows
    - Composed of basaltic lava
    - Aa flows have surfaces of rough jagged blocks
    - Pahoehoe flows have smooth surfaces and resemble twisted braids of rope

- 12 
- 13  **Aa lava flow**
- 14  **Aa lava flow**
- 15 
- 16  **A pahoehoe (basaltic) lava flow**
- 17  **A pahoehoe lava flow**
- 18  ***A rhyolite (silicic) lava flow***
- 19  **Materials Extruded During an Eruption**
- Gases
    - Gases make up 1%–6% of the total weight of a magma
    - As the magma reaches the surface and the pressure is reduced, the gases expand and escape
  - Pyroclastic Materials
    - Volcanoes eject pulverized rock and lava fragments called pyroclastic materials
    - Particles range in size from fine dust, to sand-sized ash, to very large rocks
- 20  **Materials Extruded During an Eruption**
- Pyroclastic Materials (*continued*)
    - Tephra
      - Volcanic ash – fine glassy fragments
        - Welded tuff – fused ash
      - Lapilli – walnut-sized material
      - Cinders – pea-sized material
- 21  **Ash**
- 22  ***Cinders***
- 23  **Materials Extruded During an Eruption**
- Pyroclastic Materials (*continued*)
    - Blocks – hardened or cooled lava
    - Bombs – ejected as hot lava
- 24  **A volcanic bomb**
- 25  ***A volcanic bomb in Mojave Preserve***
- 26  ***Cinders***
- 27  **Materials Extruded During an Eruption**
- Pyroclastic Materials (*continued*)
    - Pumice – light gray or pink porous rock from frothy andesitic and rhyolitic lava
    - Scoria – reddish-brown porous rock from frothy basaltic and andesitic lava
- 28  ***Pumice***
- 29  ***Scoria***
- 30  **Anatomy of a Volcano**
- 31  **Anatomy of a Volcano**
- General Features
    - Conduit – a fissure that magma moves through to reach the surface
    - Vent – the surface opening of a conduit
    - Volcanic cone – a cone of material created by successive eruptions of lava and pyroclastic material
- 32  **Anatomy of a Volcano**
- General Features (*continued*)
    - Crater – a funnel-shaped depression at the summit of most volcanic cones, generally less than 1 km in diameter
    - Caldera – a volcanic crater that has a diameter of >1 kilometer and is produced by a collapse following a massive eruption
    - Parasitic cones – a flank vent that emits lava and pyroclastic material

- Fumaroles – a flank vent that emits gases
- 33  **Shield Volcanoes**
  - General Features
    - Broad, slightly dome-shaped
    - Covers large areas
    - Produced by mild eruptions of large volumes of basaltic lava
    - Most begin on the seafloor as seamounts; only a few grow large enough to form a volcanic island
    - Examples include the Hawaiian Islands, the Canary Islands, the Galapagos, and Easter Island
    - Mauna Loa is the largest shield volcano on Earth
- 34  **Shield Volcanoes**
- 35  **Anatomy of a Shield Volcano**
- 36  **The "Big Island" of Hawaii**
- 37  **The "Big Island" of Hawaii**
- 38  **Cinder Cones**
  - General Features
    - Built from ejected lava fragments
    - Steep slope angle
    - Rather small size
    - Frequently occur in groups
    - Sometimes associated with extensive lava fields
    - Paricutin (located 320 km west of Mexico City) is an example of a cinder cone
- 39  **Cinder Cones**
- 40  **Cinder cone volcano**
- 41  **Cinder cone volcano**
- 42  **Vulcan's Throne, a cinder cone**
- 43  **Red Hill (cinder cone) and lava flow**
- 44  **Composite Volcanoes**
  - General Features
    - Also called stratovolcanoes
    - Large, classic-shaped volcano (symmetrical cone, thousands of feet high and several miles wide at the base)
    - Composed of interbedded lava flows and layers of pyroclastic debris
    - Many are located adjacent to the Pacific Ocean in the Ring of Fire
    - Mount St. Helens and Mount Etna are examples
- 45  ***Anatomy of a composite volcano***
- 46  **Composite Volcanoes**
- 47  **Mt. Shasta, California**
- 48  **Mt. Rainier, Washington**
- 49  **Mt. Lassen, California**
- 50 
- 51  ***Profiles of volcanic landforms***
- 52  **Volcanic Hazards**
  - Pyroclastic Flows
    - A pyroclastic flow is a mixture of hot gases infused with incandescent ash and lava fragments that flows down a volcanic slope
  - Lahars
    - A lahar is mudflow on an active or inactive volcano
  - Other hazards
    - Volcano-related tsunamis
    - Volcanic ash – a hazard to airplanes

- Volcanic gases – a respiratory health hazard
- Effects of volcanoes on climate

53  **Volcanic Hazards**

- Pyroclastic Flows
  - Also called a nuée ardente
  - Propelled by gravity and move similarly to snow avalanches
  - Material is propelled from the vent at high speeds (can exceed 100 km [60 miles] per hour)
    - Pyroclastic flows are typically generated by the collapse of tall eruption columns
  - A surge is a small amount of ash that separates from the main body of the pyroclastic flow
    - Occasionally, these surges have enough force to knock over buildings and move automobiles
  - In 1902, the town of St. Pierre was destroyed by a pyroclastic flow from Mount Pelée

54  **A nueé ardente on Mt. St. Helens**

55  **A nueé ardente on Mt. St. Helens**

56 

57 

58  **Volcanic Hazards**

- Lahars
  - A lahar is mudflow on an active or inactive volcano
  - Volcanic debris becomes saturated with water and rapidly moves down a volcanic slope
  - Some lahars are triggered when magma nears the surface of a volcano covered in ice and snow and causes it to melt
  - In 1985, lahars formed during the eruption of Nevado del Ruiz, killing 25,000 people
  -

59 

60  **Volcanic Hazards**

- Other hazards
  - Volcano-related tsunamis
    - Destructive sea waves can form after the sudden collapse of a flank of a volcano
  - Volcanic ash
    - Jet engines can be damaged when flying through a cloud of volcanic ash
    - In 2010, the eruption of Iceland's *Eyjafjallajokull* created a thick plume of ash over Europe, stranding hundreds of thousands of travelers
  - Volcanic gases
    - Volcanoes can emit poisonous gases, endangering humans and livestock

61 

62 

63  **Volcanic Hazards**

- Effects of volcanoes on climate
  - Ash particles released from volcanoes can reflect solar energy back into space
    - The ash from the eruption of Mount Tambora in 1815 led to the "year without summer" (1816)

64  **Other Volcanic Landforms**

- Calderas
  - Calderas: circular, steep-sided depressions with a diameter >1 km
    - Crater Lake-type calderas: Form from the collapse of the summit of a large composite volcano following an eruption; these calderas eventually fill with rainwater
    - Hawaiian-type calderas: Form gradually from the collapse of the summit of a shield volcano following the subterranean drainage of the central magma chamber
    - Yellowstone-type calderas: Form from the collapse of a large area after the discharge

of large volumes of silica-rich pumice and ash; these calderas tend to exhibit a complex history

65  **Crater Lake (Oregon)**

66  **Crater Lake (Oregon)**

67  **Crater Lake and Wizard Island, 2001**

68  **Mt. Mazama profile**

69  **Mt. Mazama profile**

70  **Hawaiian-Type Calderas**

71  **Halemaumau**

---

**a crater within Kilauea Caldera**

72  **Halemaumau, within Kilauea Caldera**

73  **Halemaumau, within Kilauea Caldera**

74  **Formation of Yellowstone-Type Calderas**

75  **Yellowstone-type Caldera formation**

76  **Yellowstone-type Caldera formation**

77  **Yellowstone-type Caldera formation**

78  **Yellowstone-type Caldera formation**

79  **Yellowstone: pyroclastic deposits**

80  **Yellowstone: pyroclastic deposits**

81  **Other Volcanic Landforms**

- Large Igneous Provinces

- Large igneous provinces cover a large area with basaltic lava

- Basaltic lava extruded from fissures blanket a large area, called a large igneous provinces or basalt plateaus

- The Columbia Plateau and the Deccan Traps are two examples

82  **Fissure eruptions**

83  **Track of the Yellowstone Hot-spot**

84  **Other Volcanic Landforms**

- Lava Domes

- A lava dome is a small dome-shaped mass composed of rhyolitic lava

- Volcanic Necks and Pipes

- A volcanic neck is the remains of magma that solidified in a volcanic conduit

- Shiprock, New Mexico, is an example

85  **A lava dome**

86  ***A lava dome near Mono Lake***

87  **Salton Buttes:**

**lava domes in our back yard...**

88  **Obsidian Butte, a lava dome**

89  ***Kimberly, South Africa***

90  ***Shiprock, New Mexico***

91  **Formation of a volcanic neck**

92  ***Devil's Tower, Wyoming***

***(neck vs. laccolith?)***

93  **Plate Tectonics and Volcanic Activity**

- Volcanism at convergent plate boundaries

- Occurs at subduction zones, where two plates converge and the oceanic lithosphere descends into the mantle

- Volcanic arcs develop parallel to the associated subduction zone trench

- The Aleutians, the Tongas, and the Marianas are examples of volcanic island arcs

- The Cascade Range is an example of a continental volcanic arc

- Most active volcanoes are found along the circum-Pacific Ring of Fire

– Eruptions tend to be explosive and associated with volatile-rich, andesitic magma

94 **Convergent Plate Volcanism**

95

96

97

98 **Plate Tectonics and Volcanic Activity**

- Volcanism at divergent plate boundaries
  - 60% of Earth’s yearly output of magma is from spreading centers
  - Characterized by a vast outpouring of fluid, basaltic lavas

99

100 **Pillow Lavas in Hawaii**

101 **Pillow Lavas in the Grand Canyon**

102 **Plate Tectonics and Volcanic Activity**

- Intraplate volcanism
  - Volcanoes that occur thousands of kilometers from plate boundaries
  - Occurs when a mantle plume ascends towards the surface
  - Examples include the Hawaiian Islands, the Columbia River Basalts, and the Galapagos Islands

•

103

104

105

106 **Track of the Yellowstone Hot-spot**

107 **Monitoring Volcanic Activity**

- Efforts aimed at detecting movement of magma from a subterranean reservoir
  - Changes in patterns of earthquakes
  - Inflation of the volcano related to rising magma
  - Changes in the amount and/or composition of gases released from the volcano
  - Increase in ground temperature
- Remote sensing devices aid in monitoring limited-accessibility volcanoes
- A volcano must be monitored for a long time to recognize a difference between “resting state” and “active state”

•

•

108 **Monitoring Volcanic Activity**

109 **Distribution of some of the world’s major volcanoes**

110

111

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