

# **Earth Science**

## **Chapter 13 - Volcanoes**

### **Section 1 – Volcanoes and Plate Tectonics**

**E.Q.: *What is volcanism and what are the tectonic settings they form in?***

#### **STANDARDS:**

**SES2. Students will understand how plate tectonics creates certain geologic features, materials, and hazards.**

- a. Distinguish among types of plate tectonic settings produced by plates diverging, converging, and sliding past each other.
- b. Relate modern and ancient geologic features to each kind of plate tectonic setting.
- c. Relate certain geologic hazards to specific plate tectonic settings.
- d. Associate specific plate tectonic settings with the production of particular groups of igneous and metamorphic rocks and mineral resources.
- e. Explain how plate tectonics creates and destroys sedimentary basins through time.

**SES5. Students will investigate the interaction of insolation and Earth systems to produce weather and climate.**

- a. Explain how latitudinal variations in solar heating create atmospheric and ocean currents that redistribute heat globally.
- b. Explain the relationship between air masses and the surfaces over which they form.
- c. Relate weather patterns to interactions among ocean currents, air masses, and topography.
- d. Describe how temperature and precipitation produce the pattern of climate regions (classes) on Earth.
- e. Describe the hazards associated with extreme weather events and climate change (e.g., hurricanes, tornadoes, El Niño/La Niña, global warming).
- f. Relate changes in global climate to variation in Earth/Sun relationships and to natural and anthropogenic modification of atmospheric composition.

#### **Objectives:**

- **Describe the three conditions under which magma can form.**
- **Explain what volcanism is.**
- **Identify three tectonic settings where volcanoes form.**
- **Describe how magma can form plutons.**

## **Volcanoes and Plate Tectonics**

- **Some volcanic eruptions can be more powerful than the explosion of an atomic bomb.**
- **The cause of many of these eruptions is the movement of tectonic plates.**
- **The movement of tectonic plates is driven by Earth's internal heat.**

## **Formation of Magma**

**magma - liquid rock produced under Earth's surface**

- **Magma can form under three conditions.**
- **First, if the temperature of the rock rises above the melting point of the minerals the rock is composed of, the rock will melt.**
- **Second, rock melts when excess pressure is removed from rock that is above its melting point.**
- **Third, the addition of fluids, such as water, may decrease the melting point of some minerals in the rock and cause the rock to melt.**

## **Volcanism**

**volcanism - any activity that includes the movement of magma toward or onto Earth's surface**

**lava magma that flows onto Earth's surface; the rock that forms when lava cools and solidifies**

**volcano a vent or fissure in Earth's surface through which magma and gases are expelled**

- **Magma rises upward through the crust because the magma is less dense than the surrounding rock.**
- **As bodies of magma rise toward the surface, they become larger in two ways.**
- **First, because they are so hot, they can melt some of the surrounding rock.**
- **Second, as the magma rises, it is forced into cracks in the surrounding rock.**

- As lava flows from an opening, or *vent*, the material may build up as a cone or material that may eventually form a mountain.

### **Major Volcanic Zones**

- Like earthquakes, most active volcanoes occur in zones near both convergent and divergent boundaries of tectonic plates.
- A major zone of active volcanoes encircles the Pacific Ocean.
- This zone, called the Pacific Ring of Fire, is formed by the subduction plates along the Pacific coasts of North America, South America, Asia, and the islands of the western Pacific.

### **Subduction Zones**

- Many volcanoes are located along *subduction zones*, where one tectonic plate moves under another.
- When a plate that consists of oceanic lithosphere meets one that consists of continental lithosphere, the denser oceanic lithosphere moves beneath the continental lithosphere.
- A deep *trench* forms on the ocean floor along the edge of the continent where the plate is subducted.
- The plates that consists of continental lithosphere buckles and folds to form a line of mountains along the edge of the continent.
- As the oceanic plate sinks into the asthenosphere, fluids such as water from the subducting plate combine with crust and mantle material.
- These fluids decrease the melting point of the rock and cause the rock to melt and form magma.
- Some of the magma breaks through the overriding plate to Earth's surface.

- Over time, a string of volcanic mountains, called an *island arc*, forms on the overriding plate.
- As more magma reaches the surface, the islands become larger and join to form one landmass, such as the volcanic islands that joined to form present-day Japan.

### Reading Check

When a plate that consists of oceanic crust and one that consists of continental crust meet, which plate subducts beneath the other plate?

*The denser plate of oceanic lithosphere subducts beneath the less dense plate of continental lithosphere.*

### Major Volcanic Zones, continued

#### Mid-Ocean Ridges

- The largest amount of magma comes to the surface where plates are moving apart at mid-ocean ridges.
- This magma erupts to form underwater volcanoes.
- Most volcanic eruptions that happen along mid-ocean ridges are unnoticed by humans because the eruptions take place deep in the ocean.

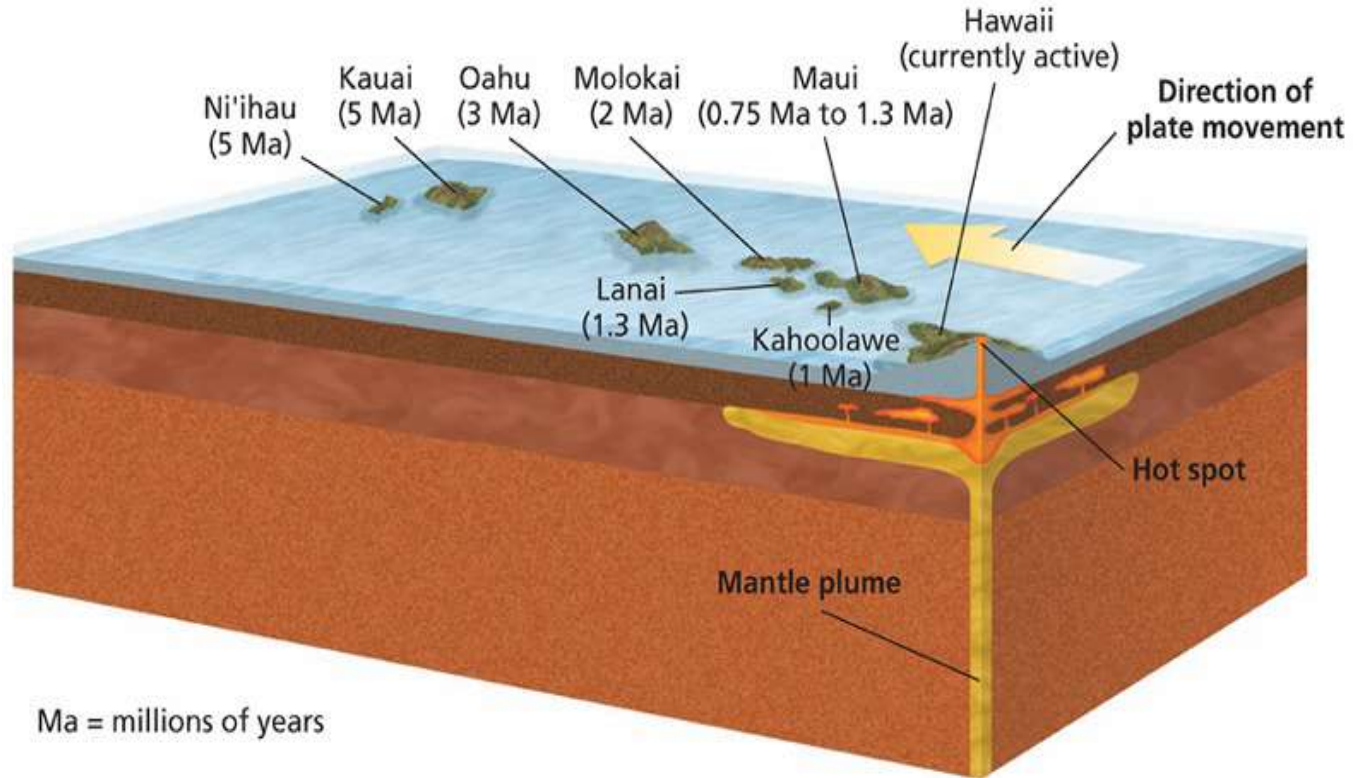
#### Hot Spots

hot spot - a volcanically active area of Earth's surface, commonly far from a tectonic plate boundary

- Most hot spots form where columns of solid, hot material from the deep mantle, called *mantle plumes*, rise and reach the lithosphere.
- As magma rises to the surface, it breaks through the overlying crust. Volcanoes can then form in the interior of a tectonic plate.
- However, the lithospheric plate above a mantle plume continues to drift slowly.
- So, the volcano on the surface is eventually carried away from the mantle plume.

- The activity of the volcano stops because a hot spot that contains magma no longer feeds the volcano.
- However, a new volcano forms where the lithosphere has moved over the mantle plume.

**The diagram below shows hot spots and mantle plumes.**



## **Reading Check**

**Explain how one mantle plume can form several volcanic islands.**

**As the lithosphere moves over the mantle plume, older volcanoes move away from the mantle plume. A new hot spot forms in the lithosphere above the mantle plume as a new volcano begins to form.**

## **Intrusive Activity**

- As magma moves upward, it comes into contact with, or *intrudes*, the overlying rock.
- Because of magma's high temperature, magma affects surrounding rock in a variety of ways.

- Rock that falls into the magma may eventually melt, or the rock may combine with the new *igneous rock*, which is rock that forms when the magma cools.
- When magma does not reach Earth's surface, the magma may cool and solidify inside the crust.
- This process results in large formations of igneous rock called *plutons*.
- Small plutons called *dikes* are tabular in shape and may be only a few centimeters wide.
- *Batholiths* are large plutons that cover an area of at least 100 km<sup>2</sup> when they are exposed to Earth's surface.