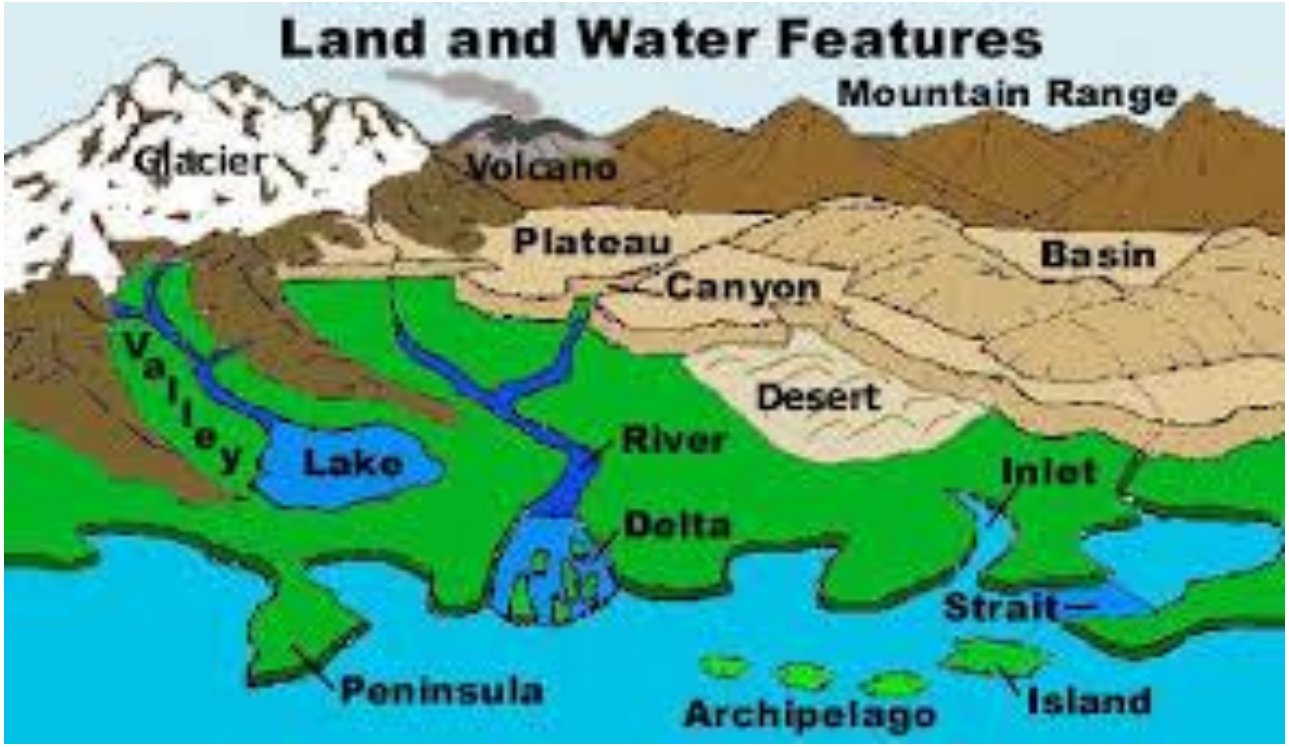
Lesson 3

Forces That Build the Land

Main Idea

- Many landforms result from changes and movements in Earth's crust.

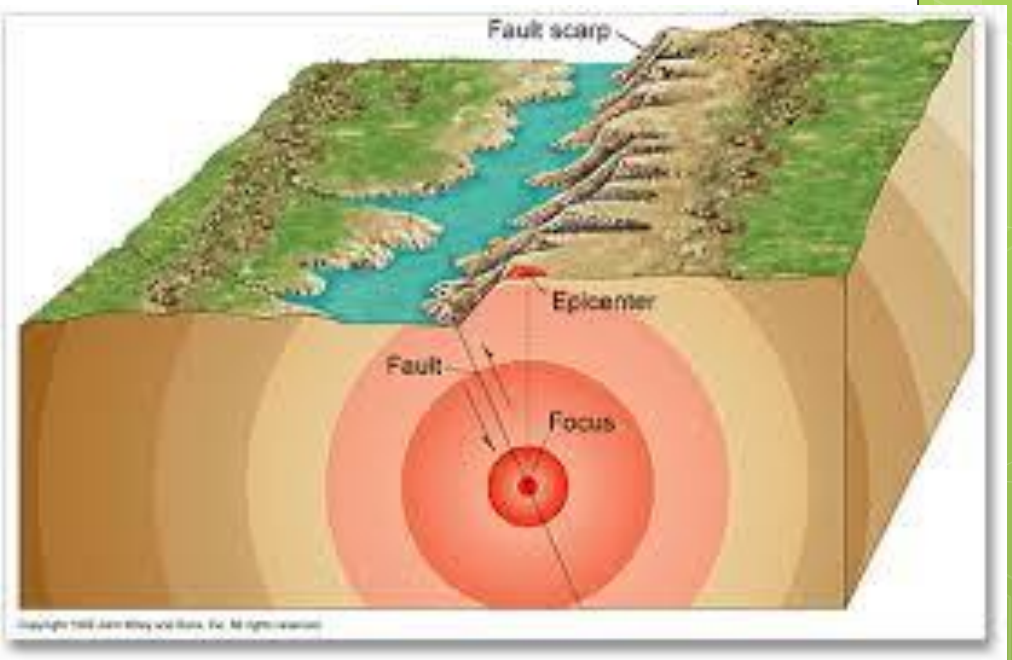


Objectives

- Identify types of landforms and the processes that form them.
- Describe what happens when an earthquake occurs.

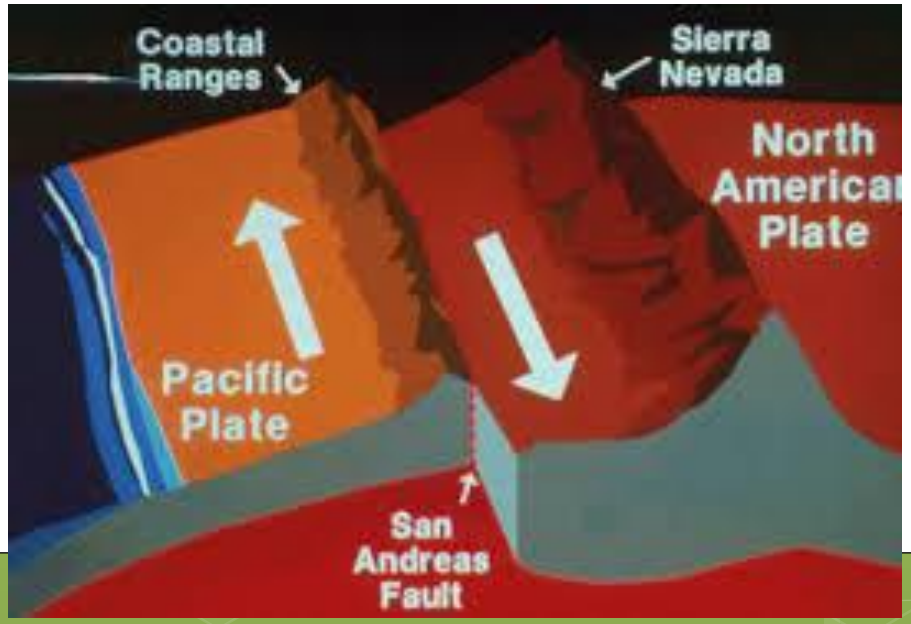
Vocabulary

- fault
- focus
- aftershock
- seismic wave
- epicenter
- seismograph
- magnitude
- vent

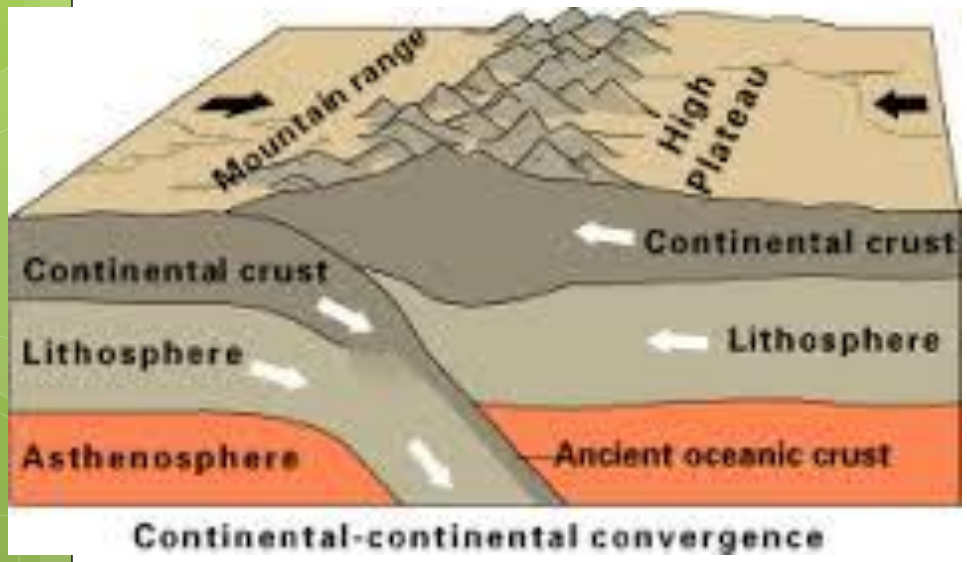


What forces change Earth's crust?

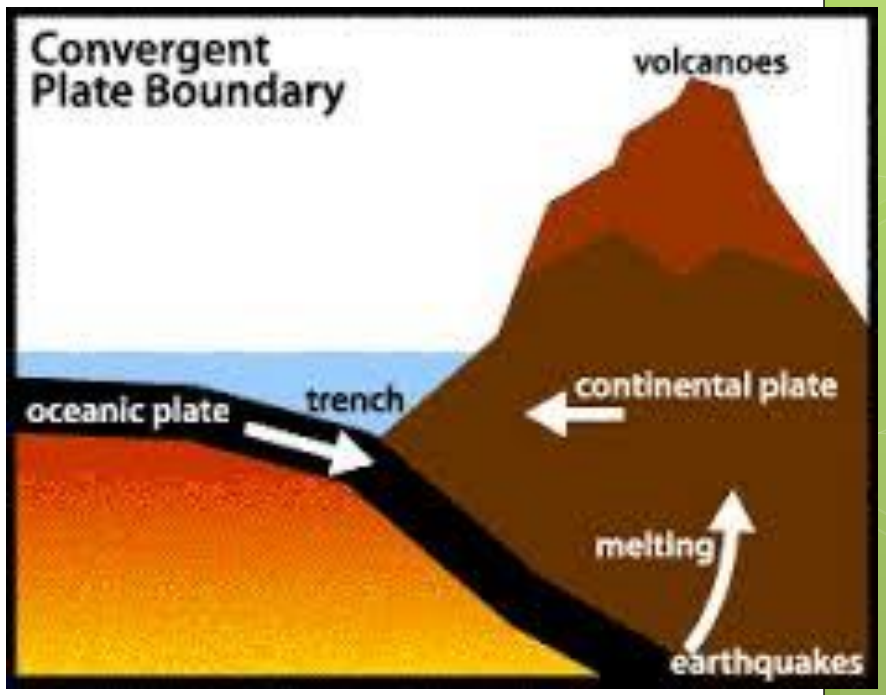
At transform boundaries, the pieces of rock rub together in a force called *shearing*, like the blades of a pair of scissors, causing the rock to break.



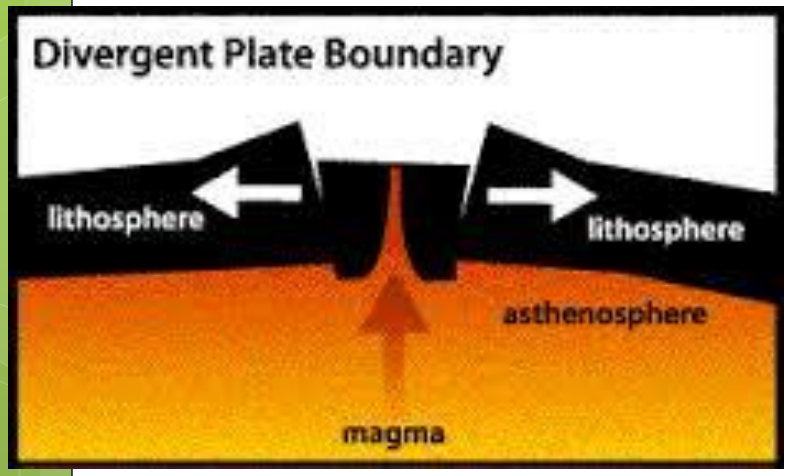
At convergent boundaries, plates collide and this force is called *compression*, squeezing the rock together.

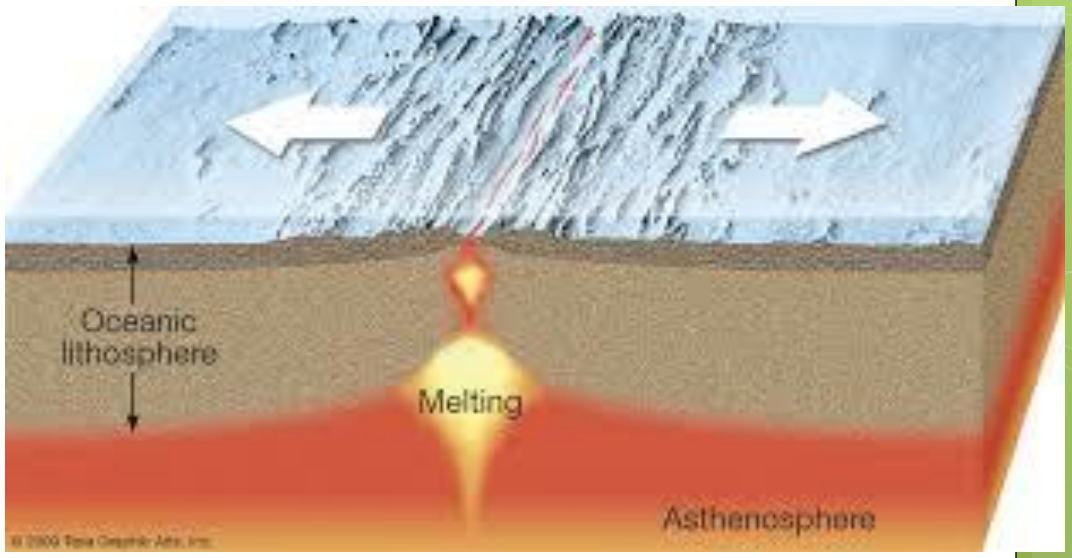


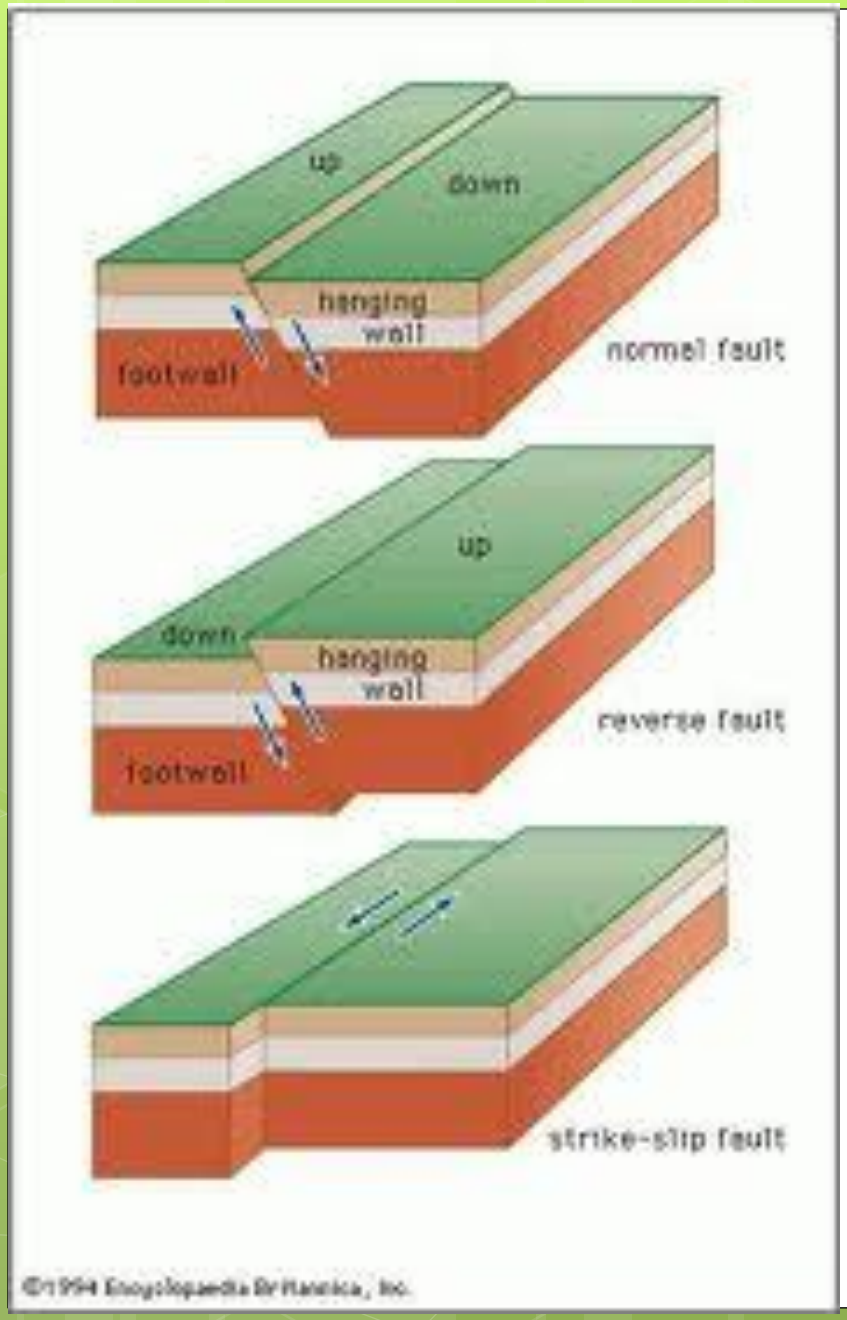
Continental-continental convergence



At divergent boundaries, plates separate causing *tension*, making the crust longer and thinner eventually breaking and creating a fault.







Faults are usually located along the boundaries between tectonic plates.

Three Kinds of Faults

- Shearing forms *strike-slip faults*.
- Tension forms *normal faults*.
  - The rock above the fault moves down.
- Compression forms *reverse faults*.
  - The rock above the fault moves up.

Uplifted Landforms

- *Folded mountains* are mostly made up of rock layers folded by being squeezed together.

- *Fault-block mountains* are made by huge, tilted blocks of rock separated from the surrounding rock by faults.

- The Colorado Plateau was formed when rock layers were pushed upward.
- The Colorado River eventually formed the Grand Canyon.

Quick Check

Infer

Why are faults often produced along plate boundaries?

Forces act on the crust most directly at plate boundaries, because these locations are where plates are moving, relative to each other.

Critical Thinking

Why do some mountains form as folded mountains and others form as fault-block mountains?

Compression forces form folded mountains, and tension forms fault-block mountains. Differences in forces, rather than in rock type or duration of the forces, cause formation of these two types of mountains.

What are earthquakes?

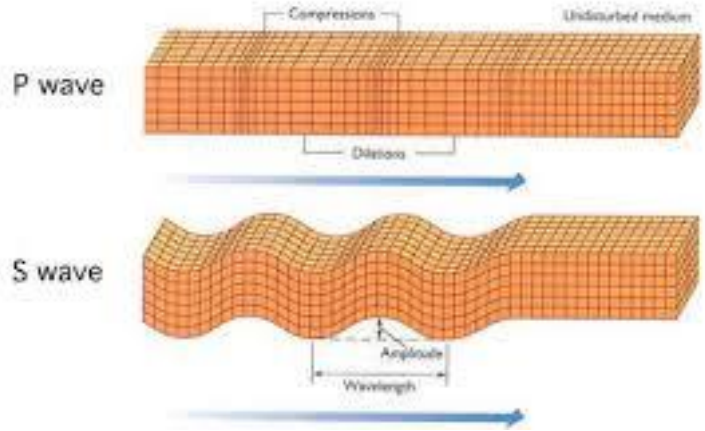
Most earthquakes occur when the ground near tectonic plates shifts and changes position.

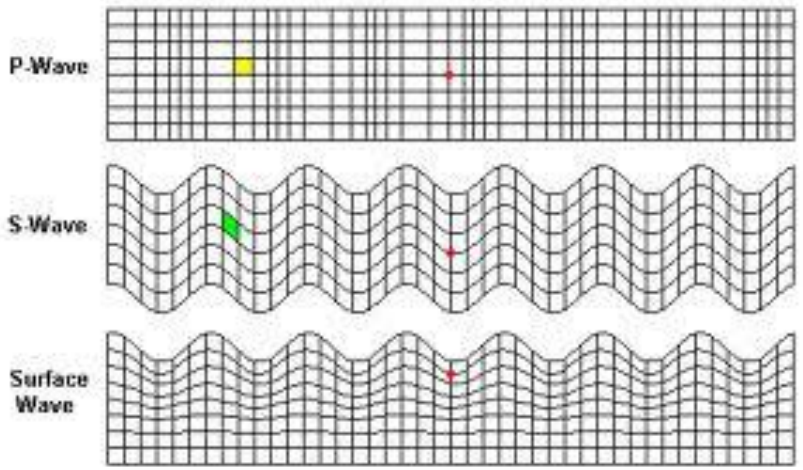
Some occur away from plate boundaries. The condition of rocks and soil may cause movements and shifting that can produce earthquakes.

Energy can build up for years, even decades. When the rock breaks or slips, energy is released, and Earth's crust moves.

After shocks can be as strong as the original earthquake and can continue for days, weeks, or months.

Earthquake Waves





- Seismic waves spread out in all directions from the focus.
- People at or near the epicenter are the first to feel the earthquake.

Quick Check

Infer

Why do most earthquakes occur near or along a fault?

Movement along a fault produces pressure and stress on the rock. Too much stress causes the rock to break and shift rapidly, resulting in earthquakes.

Critical Thinking

Do all earthquakes occur at plate boundaries? How do you know?

No. "Earthquakes can also occur away from plate boundaries." The movement and shifting of rocks and soil can cause earthquakes.

What can we learn from seismographs?

Earthquakes cause different types of seismic waves, two of them are: surface waves and body waves.

Surface waves are generally the most destructive. They move slowly and travel along the surface like ripples on a pond.

Body waves travel through the interior of Earth.

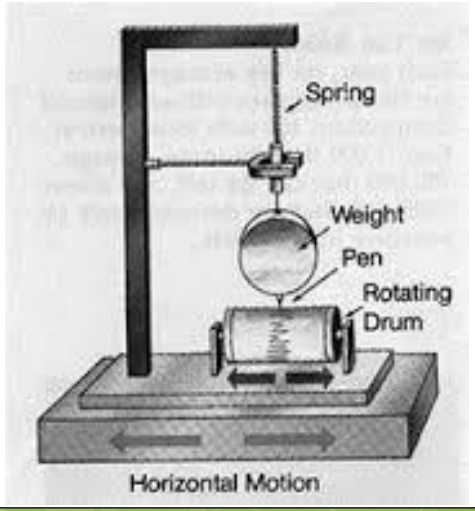
There are two types: primary waves (p waves) and secondary waves (s waves)

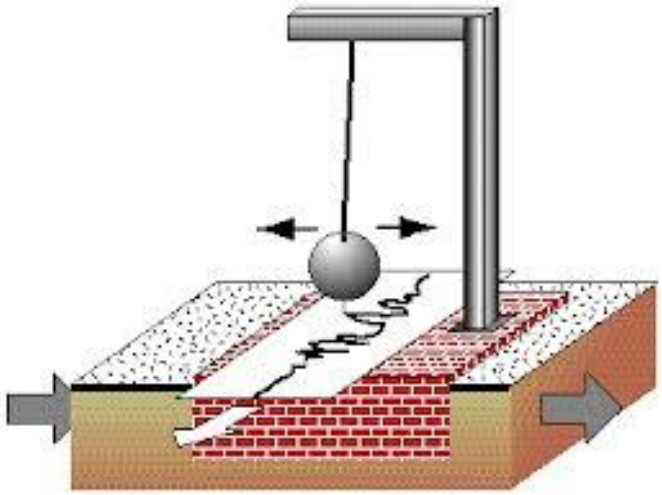
- P waves
  - are the fastest
  - travel through gases, liquids, and solids
  - push (compress) and pull (stretch) against the material they pass through
  - cause the material to vibrate in the direction in which the waves are moving
  - move in the same direction as the shaking rock

- S waves
  - slower than p waves
  - only travel through solids
  - moving ahead create vibrations that move up and down or side to side
  - cause the solids to vibrate at a right angle to their direction of travel

A seismograph detects, measures, and records the energy of earthquake vibrations.

It can also help find the earthquake's epicenter.





Locating the Epicenter of an Earthquake

- Scientists measure how long it takes the waves to reach each station.
- The distance is charted around each station in a circle.
- The point where the three circles intersect is the epicenter.

Quick Check

- Infer
  - Look at the waves plotted by the seismograph below. Which waves look as though they would be the most destructive?
    - The waves indicated by the longest lines.

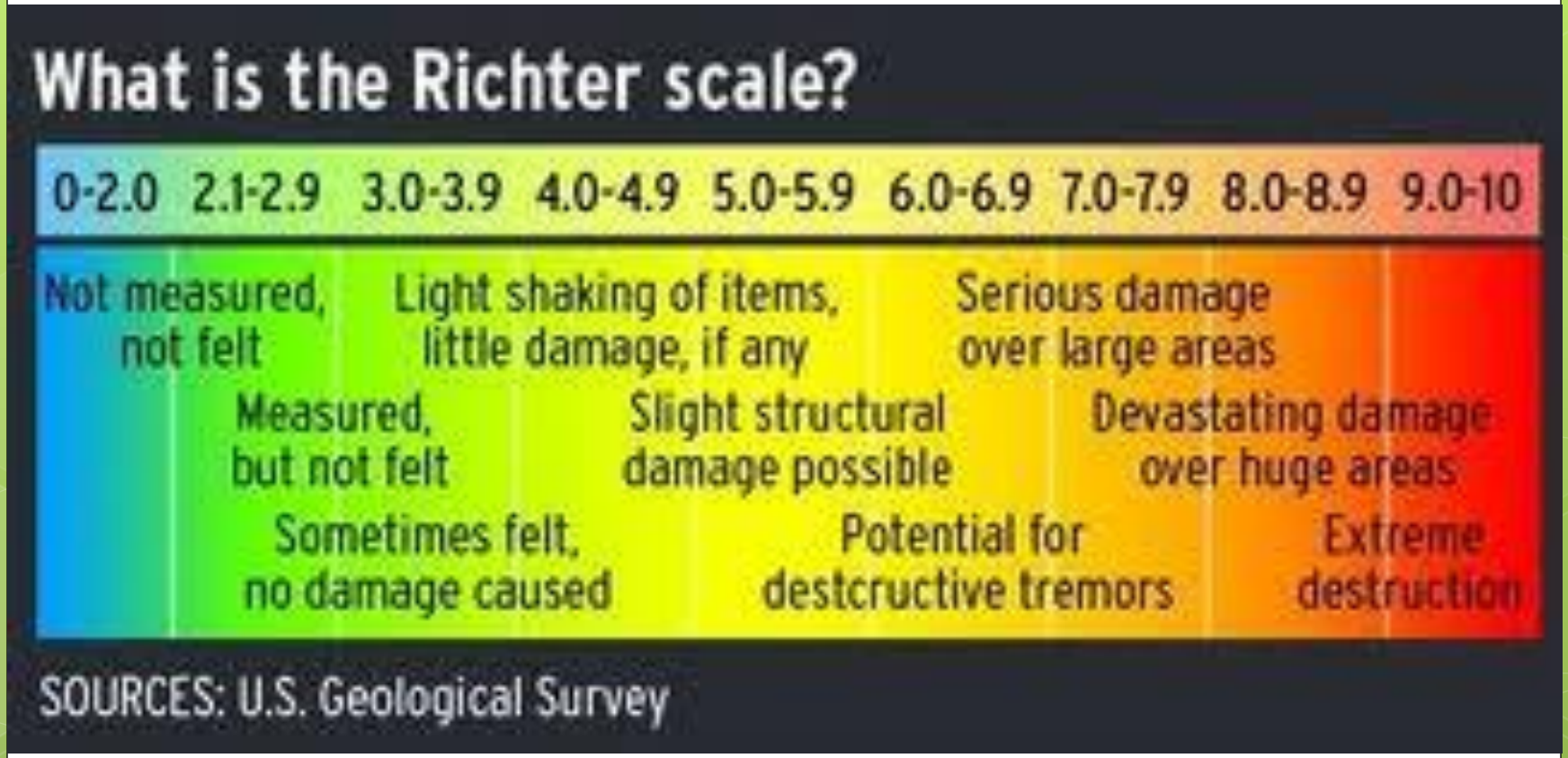
- Critical Thinking
  - Why are three stations needed to locate the epicenter of an earthquake?
    - Seismographs at one station can find the distance of an earthquake but not its location. There is only one point where all three of the seismograph's circles will intersect and that is the location of the epicenter.

How destructive is an earthquake?

The height of a wave on a seismograph indicates how much energy is released during an earthquake called the magnitude.

Two Measures of Earthquakes

- Richter scale
  - Measures the magnitude on a scale from 1 to 10
    - An increase of 1 means a tenfold increase


What is the Richter scale?
0-2.0
2.1-2.9
3.0-3.9
4.0-4.9
5.0-5.9
6.0-6.9
7.0-7.9
8.0-8.9
9.0-10
Not measured, not felt
Measured, but not felt
Sometimes felt, no damage caused
Light shaking of items, little damage, if any
Slight structural damage possible
Potential for destcructive tremors
Serious damage over large areas
Devastating damage over huge areas
Extreme destruction
SOURCES: U.S. Geological Survey

- Mercalli scale
  - Measures the intensity felt on the Earth's surface
    - Rates what people see and feel not mathematics
      - Less reliable than the Richter scale

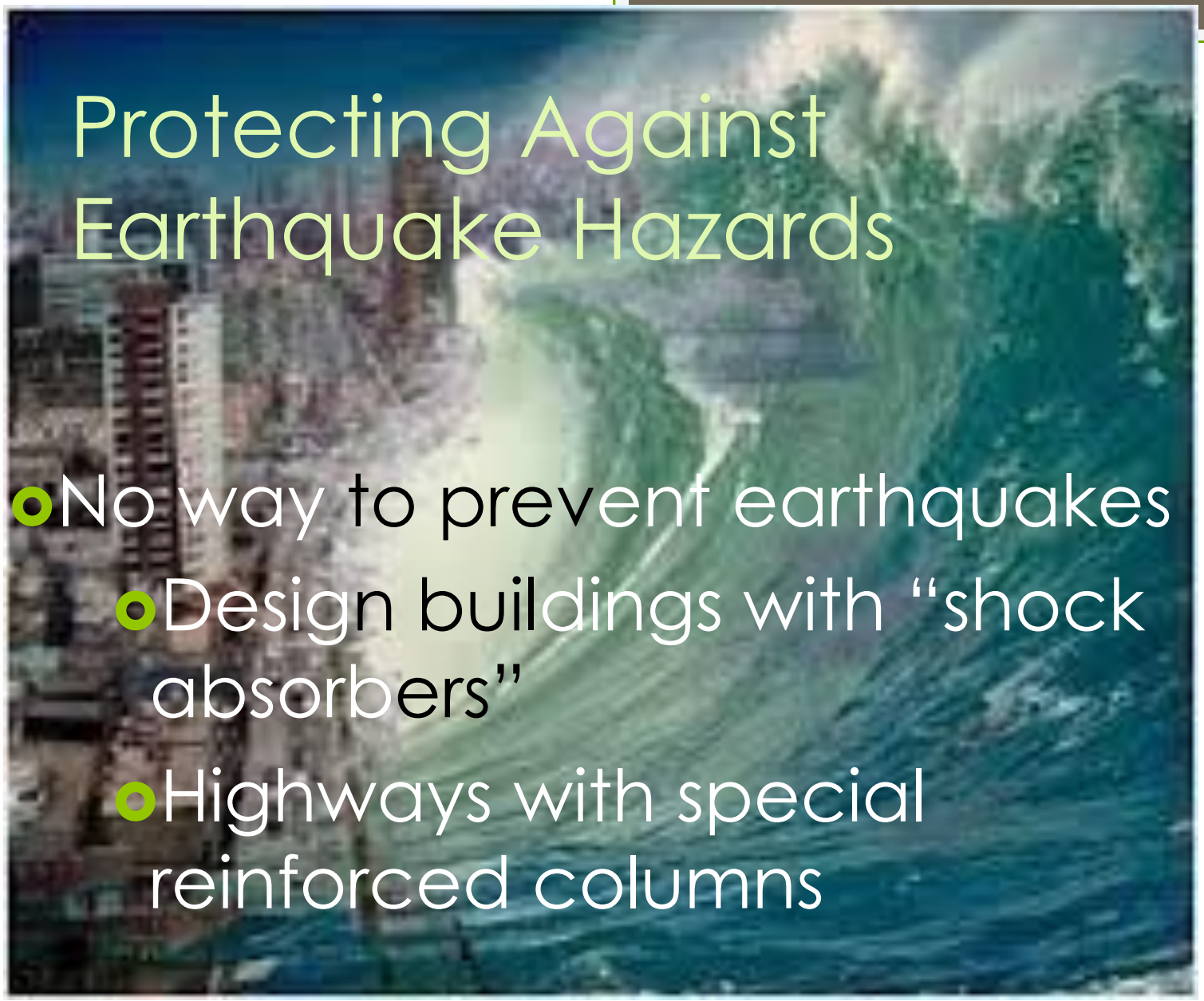
Modified Mercalli Intensity Scale

I	Not felt
II	Felt only by persons at rest
III–IV	Felt by persons indoors only
V–VI	Felt by all; some damage to plaster, chimneys
VII	People run outdoors, damage to poorly built structures
VIII	Well-built structures slightly damaged; poorly built structures suffer major damage
IX	Buildings shifted off foundations
X	Some well-built structures destroyed
XI	Few masonry structures remain standing; bridges destroyed
XII	Damage total; waves seen on ground; objects thrown into air

Tsunamis

- a series of huge waves caused by an earthquake or volcanic eruption
- move away from the epicenter in all directions
- have long wavelengths and low amplitudes (wave heights)
- speed depends on the depth of the water
- slow down as they approach the shore
- wave length decreases and height increases
- water piles up when it is pulled away from the coastline and crashes onto the shore

Protecting Against Earthquake Hazards



- No way to prevent earthquakes
  - Design buildings with "shock absorbers"
  - Highways with special reinforced columns

Quick Check

- Infer
  - During an earthquake, a refrigerator moves, and pictures fall off the wall. How strong is the earthquake?
    - About VI on the Mercalli scale; about 5 or 6 on the Richter scale

- Critical Thinking
  - Why is it useful to have two scales for measuring earthquakes?
    - The Richter scale measures the energy of an earthquake but not the damage it causes. Earthquakes with the same energy can have different effects, depending on the rock types or other factors in an area.

How do volcanoes form?

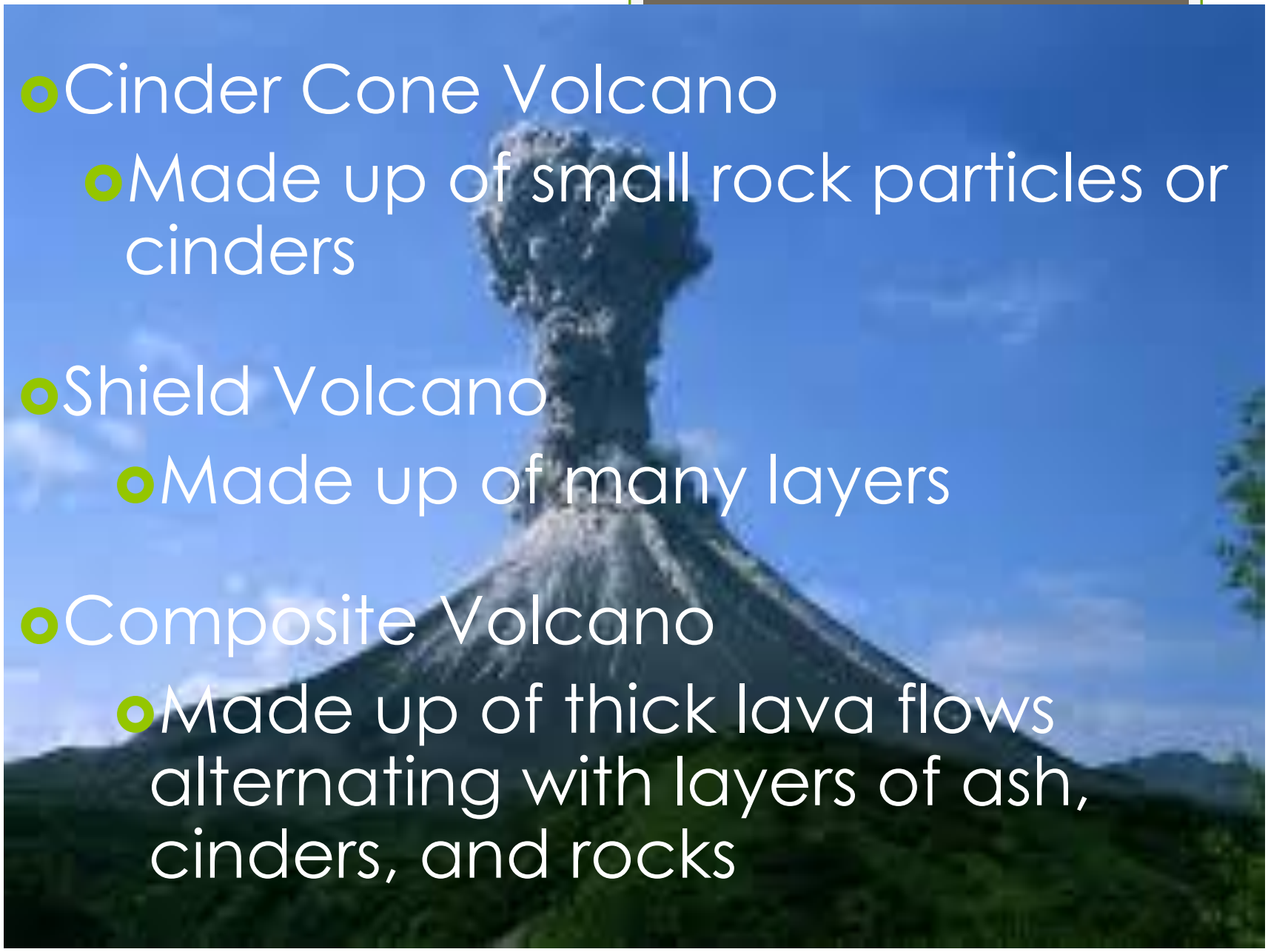
- As the rock in the mantle and lower crust melts it produces gases that mix with magma.
- The gas filled magma is less dense than the rock surrounding which allows it to rise.
- The rising magma forms a magma chamber, a reservoir, from which the magma erupts.

- The magma erupts through a vent and is called lava upon reaching the surface.
- The lava cools and hardens, after many eruptions forms a mound.
- The space around the vent at the top of the volcano is called a crater.

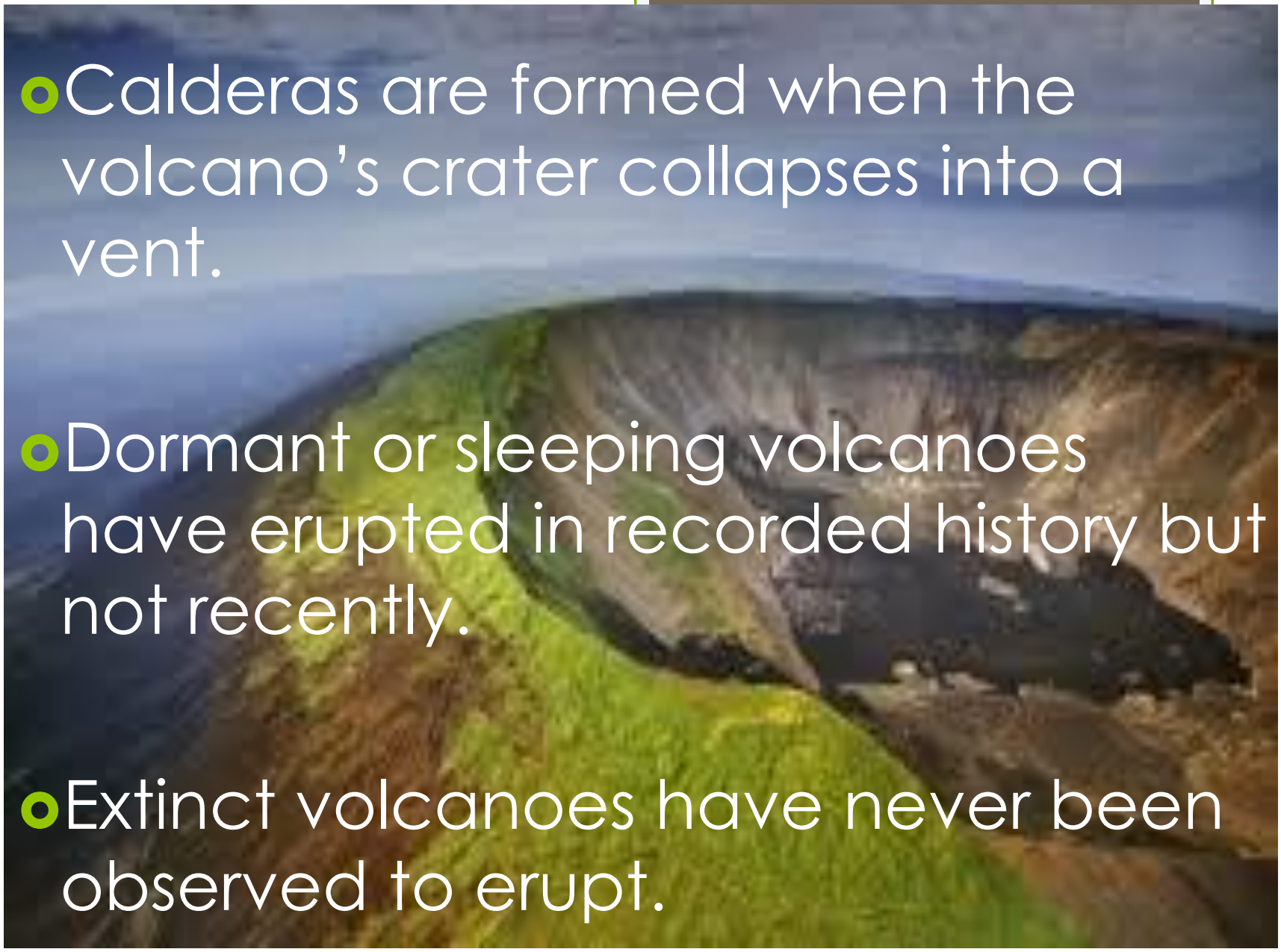
- Volcanoes that form in the middle of a plate are believed to be formed by hot spots.

Types of Volcanoes

- Cinder cone volcano
- Shield volcano
- Composite volcano

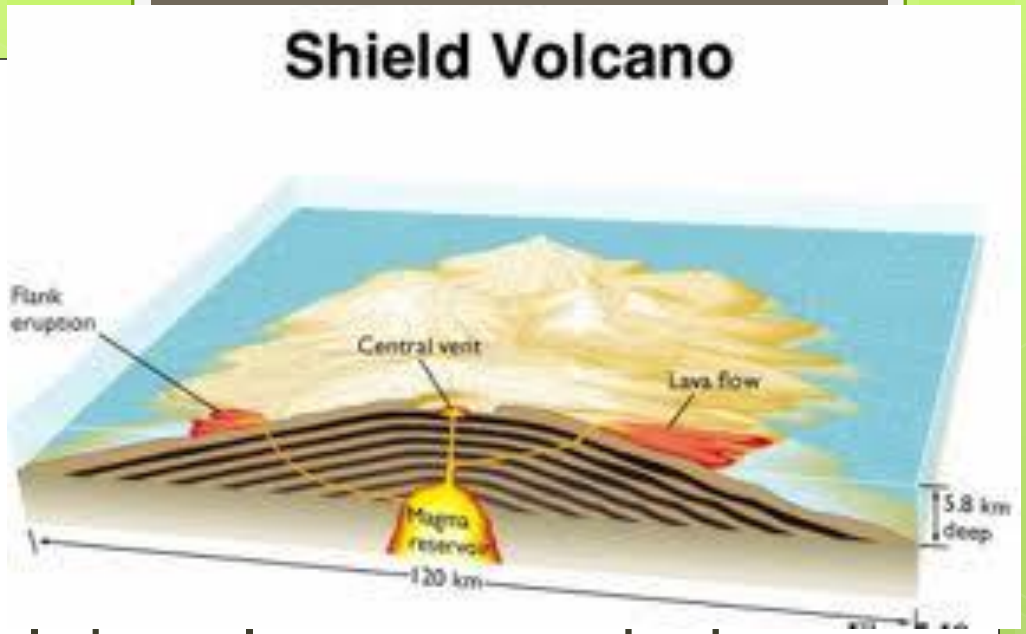


- Cinder Cone Volcano
  - Made up of small rock particles or cinders
- Shield Volcano
  - Made up of many layers
- Composite Volcano
  - Made up of thick lava flows alternating with layers of ash, cinders, and rocks



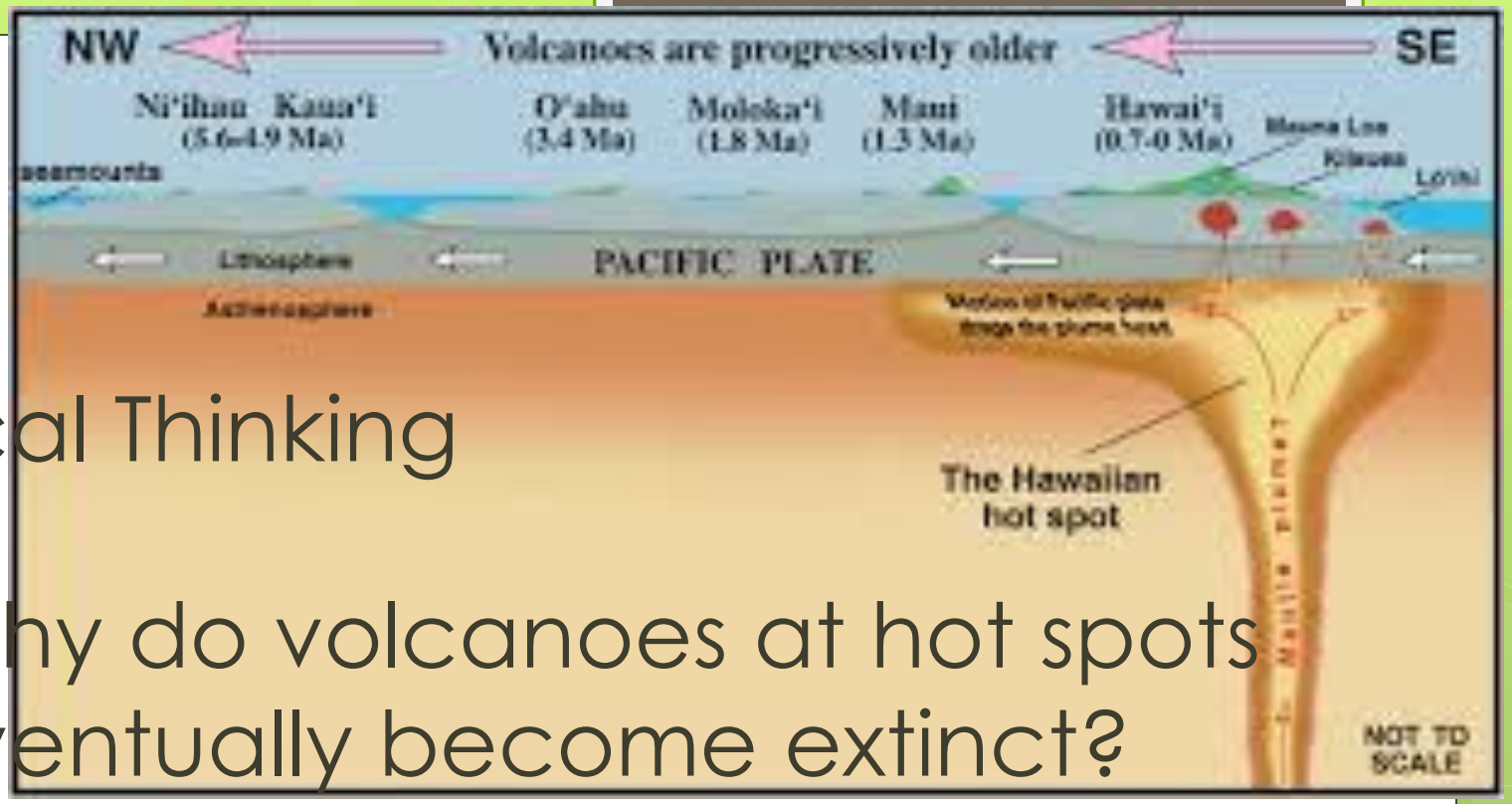
- Calderas are formed when the volcano's crater collapses into a vent.
- Dormant or sleeping volcanoes have erupted in recorded history but not recently.
- Extinct volcanoes have never been observed to erupt.

Quick Check



- Infer
  - Why do shield volcanoes take a long time to form?
    - Shield volcanoes take a long time to build up because they are built up from successive layers of lava rock.

- Critical Thinking
  - Why do volcanoes at hot spots eventually become extinct?
    - The plate eventually moves past the hot spots, so the magma flow through the volcano subsides.



What are other volcanic landforms?

- Island arc, a string of island volcanoes, forms when one oceanic plate is driven under another.
- Rift volcanoes form at gaps along the plate edges when the plates move apart

- Dome mountains are created when magma rises and pushes against the rock layers above it.
- Dikes are formed when magma hardens in vertical cracks across horizontal layers.
- Sills are created when magma hardens along horizontal layers of rock.
- Laccoliths are formed by sills that build up and push upwards.
- Batholiths are large pockets of magma that are deep in the crust.

Quick Check

- Infer
  - Why do so many island chains and island arcs form in the Pacific Ocean?
    - One oceanic plate sinking under another gives rise to island chains and arcs. This land formation occurs often in areas of the Pacific Ocean, where there is a higher level of seismic activity.

- Critical Thinking
  - What is the relationship between active volcanoes and earthquakes?
    - Most volcanoes and earthquakes are located at plate boundaries. Active volcanoes can cause earthquakes.