Volcanoes and Earthquakes

June 2nd, 2021

Volcanism

It is general term that refers to all phenomena connected with the origin and movement of **magma** from the interior of the Earth to or near the surface.

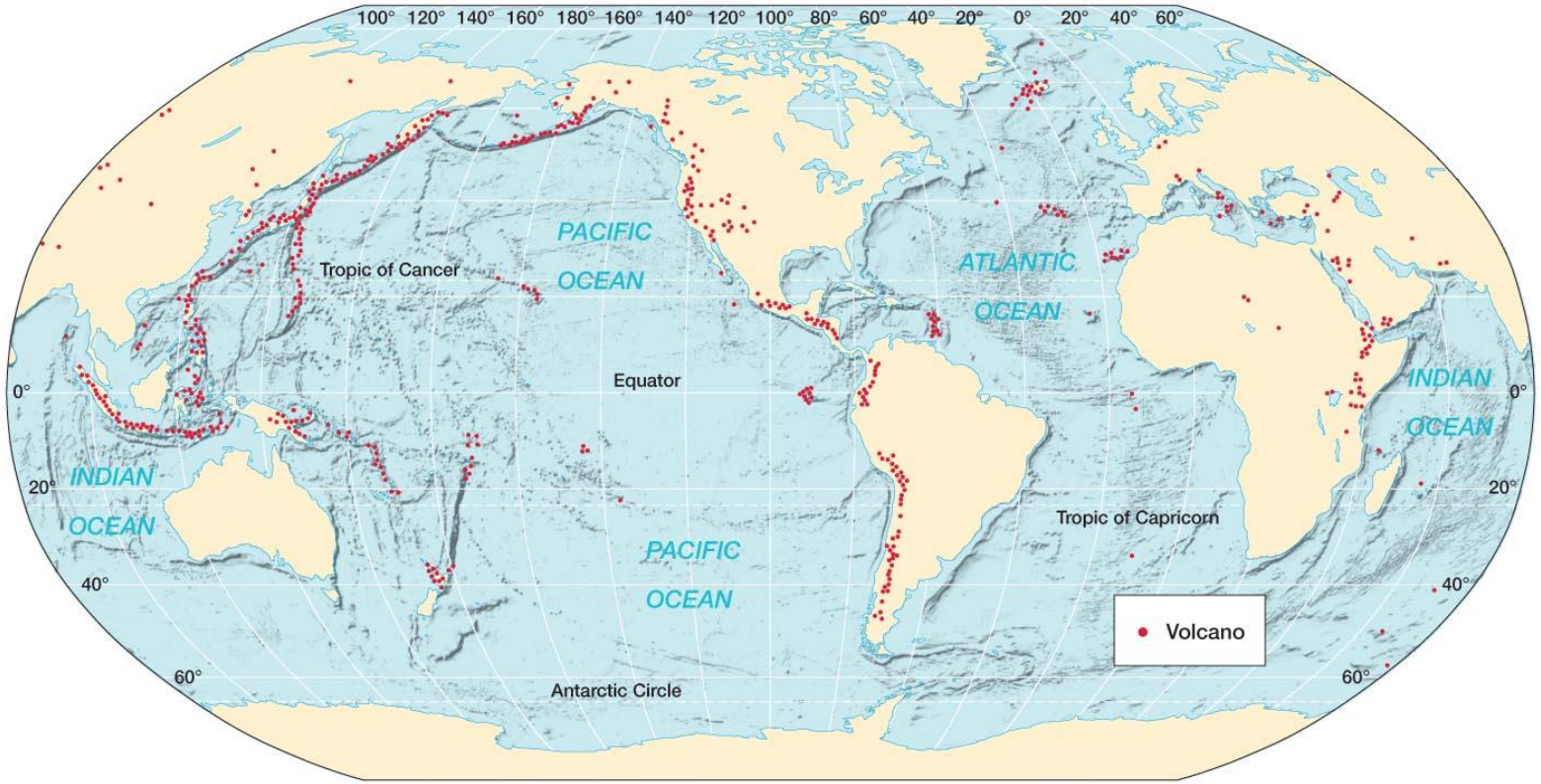
Magma: molten mineral material below the Earth surface

Volcanism

- Three types of volcanism:
  1. **Volcanism**—extrusive volcanism, in that the magma is expelled onto Earth's surface while still molten.
  2. **Intrusive volcanism**—occurs where magma solidifies in shallow crust near the surface.
  3. **Plutonic activity**—occurs where magma solidifies very deep inside the Earth, far below the surface.

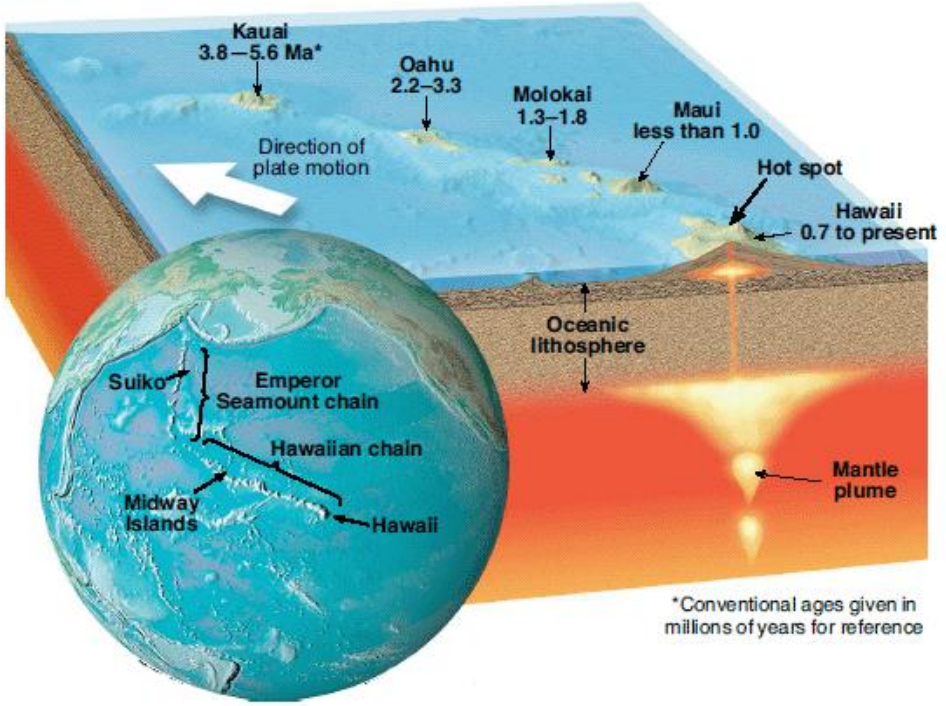
Volcanism

Global volcano distribution



Where are volcanoes likely to occur?

- **Along subduction boundaries** at ***Continental –Oceanic plate convergence*** (such as Mount St. Helens) or Oceanic plate – Oceanic Plate Convergence (Philippines and Japan).
- **Along sea-floor spreading centers** (Iceland and the mid-Atlantic ridge) or off the coast of Oregon and Washington or areas of rifting on continental plates (the rift zones in east Africa).



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Where are volcanoes likely to occur?

At hot spots – where individual plumes of magma rise to the crust (such as Hawai'i and Yellowstone National Park).

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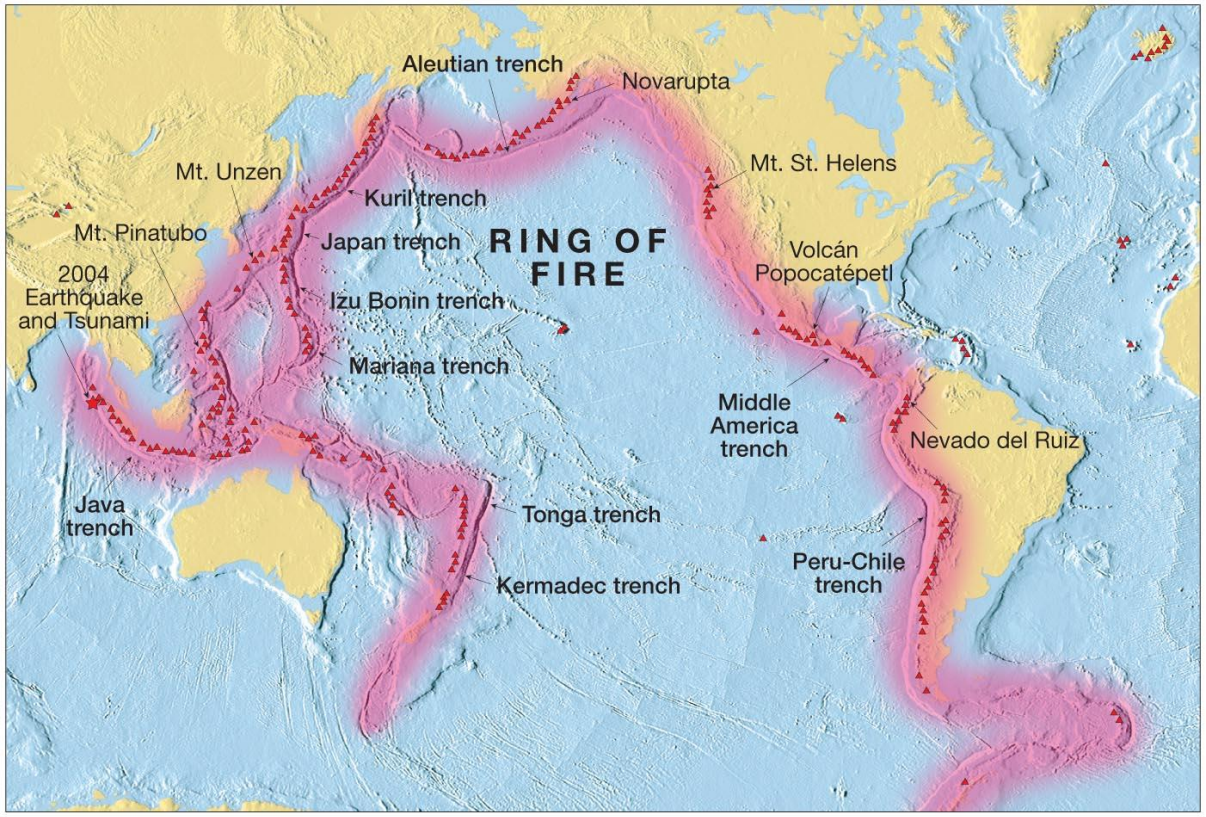
Plate Tectonics

- **The Pacific Ring of Fire**
  - Plate boundaries exist all around the Pacific Rim
  - **Primarily subduction zones**
  - 75% of all volcanoes lie in the Ring of Fire



Volcanism

- **Lava**: **molten magma** that is extruded onto the surface of the Earth, where it cools and solidifies; affects landscape whether gentle or explosive.
- *Violent or gentle eruptions*
- **Pyroclastic mater**ial: solid material such as rock fragments, solidified lava blobs, and dust thrown into the air by volcanic explosions.
- Gases, and steam may also be ejected
- Some self destruct (e.g. Krakatau in 1883)

Magma chemistry and styles of eruption

- Nature of eruption is determined by magma chemistry and by confining pressure
- Quantity of silica in magma appears critical for the strength of volcanoes:
  - High silica magma—felsic magma—granite
  - Intermediate silica—andesitic magma—diorite
  - Low silica—mafic magma—basalt
- High silica eruptions—pyroclastic – violent
- Low silica eruptions—quiet, nonexplosive
- Intermediate—some combination of the two

Volcanism

- **Volcanic activity**
  - Relatively temporary features on the landscape: from a few years to sporadically to thousands of centuries
  - Much of Earth's water originated from water vapor from volcanic eruptions
  - Magma contains major elements required for plant growth
    - Provides soil fertility

TABLE 14-1 Principal Types of Volcanoes

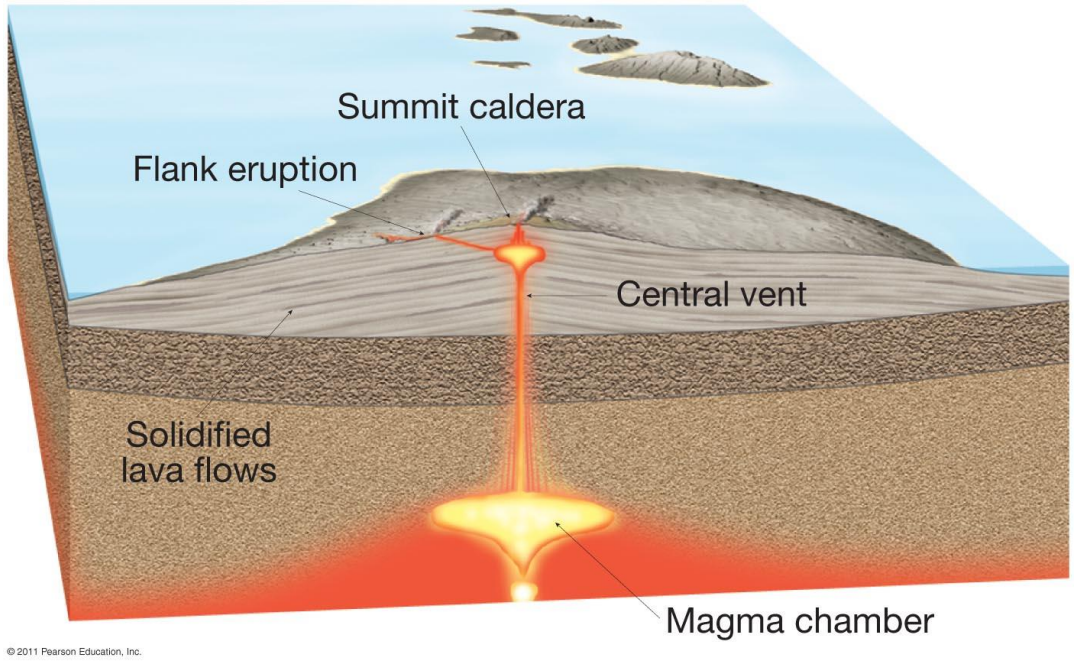
Volcano Type	Shape and Size	Structure	Magma and Eruption Style	Examples
Shield	Broad, gently sloping mountain; much broader than high; size varies greatly.	Layers of solidified lava flows.	Magma usually basaltic; characterized by quiet eruptions of fluid lava.	Hawaiian Islands; Tahiti
Composite (Stratovolcano)	Steep-sided symmetrical cone; heights to over 3700 m (12,000 ft.).	Layers of lava flows, pyroclastics, and hardened mudflow deposits.	Magma usually intermediate in chemistry, often andesitic; long life span; characterized by both explosive eruptions of pyroclastics and quiet eruptions of lava.	Mt. Fuji, Japan; Mt. Rainier, Washington; Mt. Shasta, California; Mt. Vesuvius, Italy; Mt. St. Helens, Washington
Lava Dome (Plug Dome)	Usually small, typically less than 600 m (2000 ft.) high; sometimes irregular shape.	Solidified lava that was thick and viscous when molten; plug of lava often covered by pyroclastics; frequently occur within the crater of composite volcano.	Magma usually high in silica, often rhyolitic; dome grows by expansion of viscous lava from within; explosive eruptions common.	Lassen Peak, California; Mono Craters, California
Cinder Cone	Small, steep-sided cone; maximum height 500 m (1500 ft.).	Loose pyroclastic material; may be composed of ash or cinder-size pieces.	Chemistry of magma varies, often basaltic; short life span; pyroclastics ejected from central vent; occasionally produce lava flows.	Paricutin, Mexico; Sunset Crater, Arizona

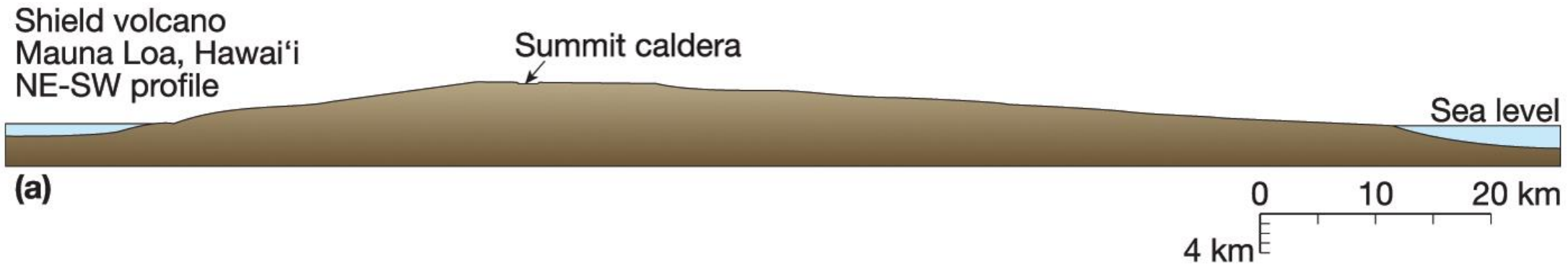
Types of Volcanoes

Types of Volcanoes

Shield volcanoes

- Layer upon layer of solidified lava flows
- Broad, low-lying shield
- Never steep-sided
- ***Little pyroclastic material***
- Hawaiian islands are an example

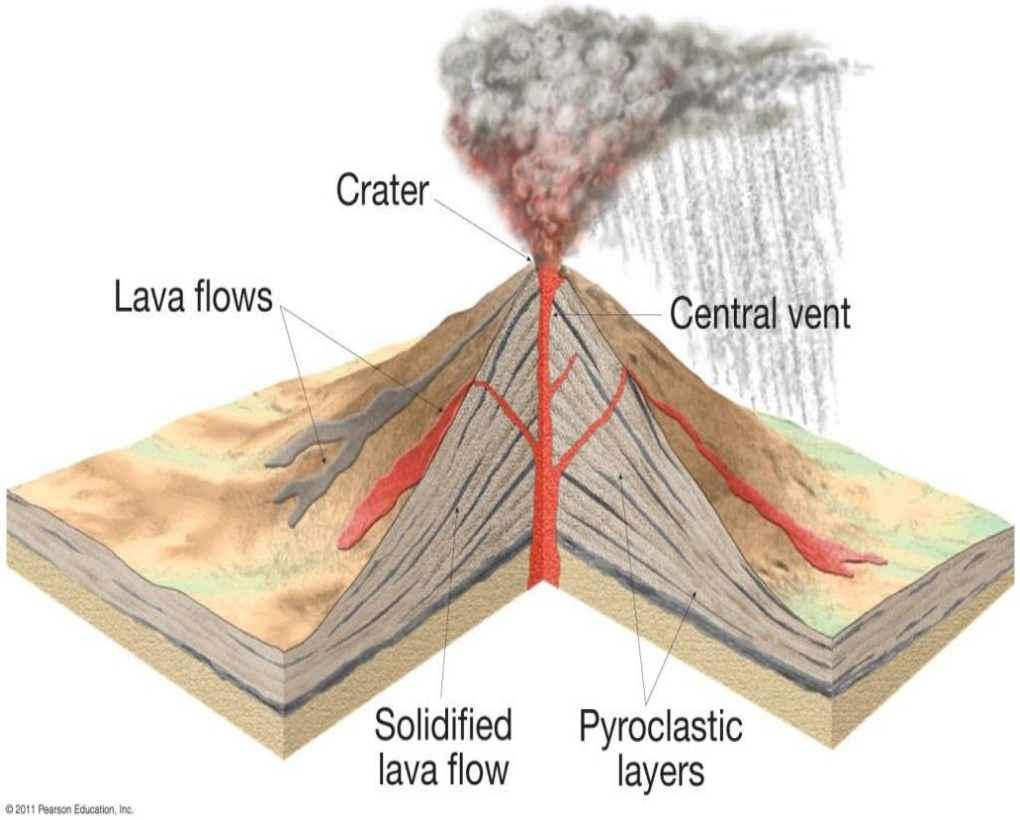


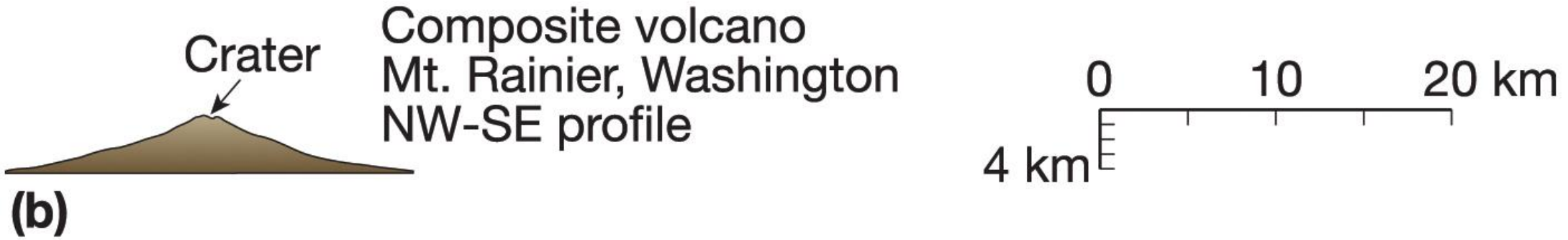

Shield volcano
Mauna Loa, Hawai‘i
NE-SW profile
Summit caldera
Sea level
(a)
0
10
20 km
4 km

Types of Volcanoes

–Composite Volcano

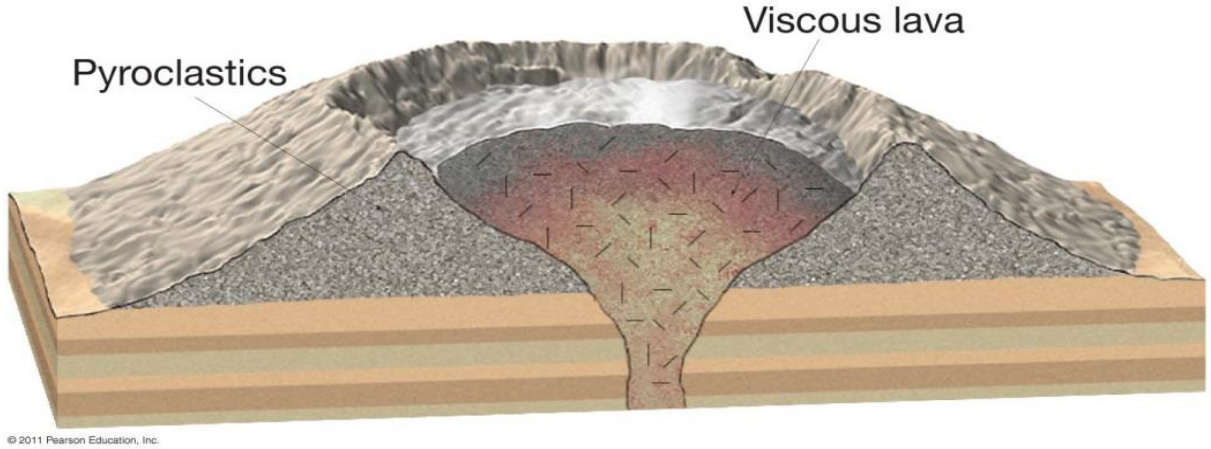
- Emit higher silica lavas (andesite lava or intermediate)
- Erupt explosively and tend to develop into symmetrical, steep-sided volcanoes also called ***stratovolcanoes.***
- Steep sided mountains
- Pyroclastics from explosive lava flows alternate with nonexplosive flows
- Pyroclastic flows produce steep slopes, lava holds it together.




Crater
Composite volcano
Mt. Rainier, Washington
NW-SE profile
0
10
20 km
4 km
(b)

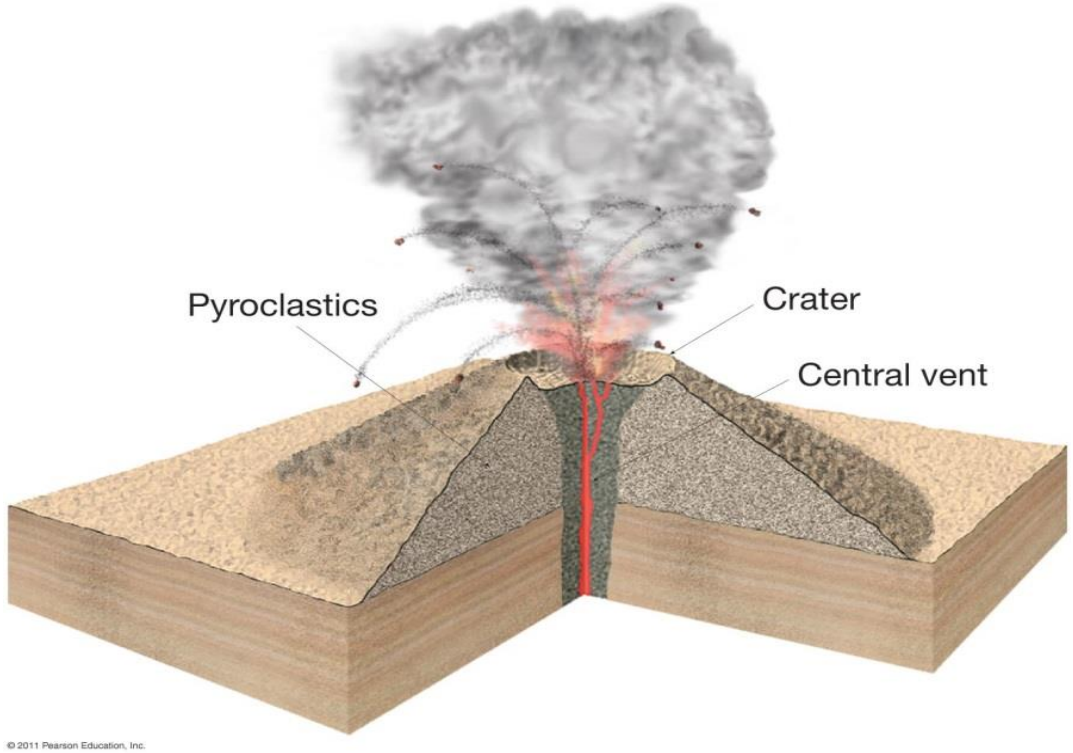
Types of Volcanoes

- **Lava domes**
  - Plug volcanoes
  - Masses of very viscous lava that do not flow far
  - Lava bulges from the vent, dome grows by expansion from below and lava within
  - Some lava domes form inside of composite volcanoes



Types of Volcanoes

- **Cinder cones**
  - Smallest volcanic mountains
  - Magma chemistry vary, but basaltic magma is common
  - Cone-shaped peaks built by unconsolidated pyroclastic materials
  - Size of particles being ejected determines the steepness of slopes
  - Tiny particles (ash) = 35-degree slopes; larger materials = 25-degree slopes
  - Generally found in association with other volcanoes



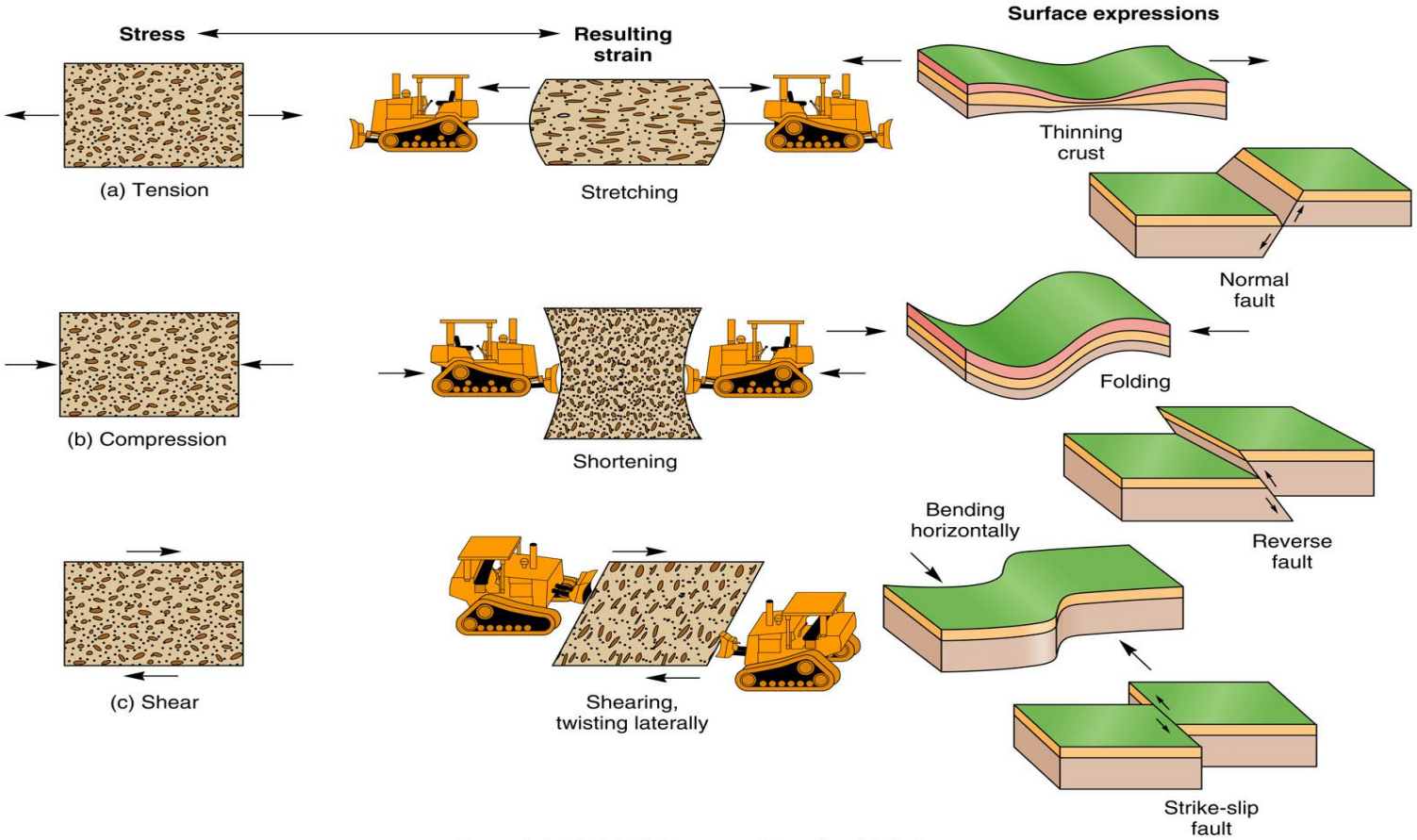

Crater
Cinder cone
Sunset Crater, Arizona
N-S profile
0
10
20 km
4 km

(c)

Diatrophism (Tectonism)

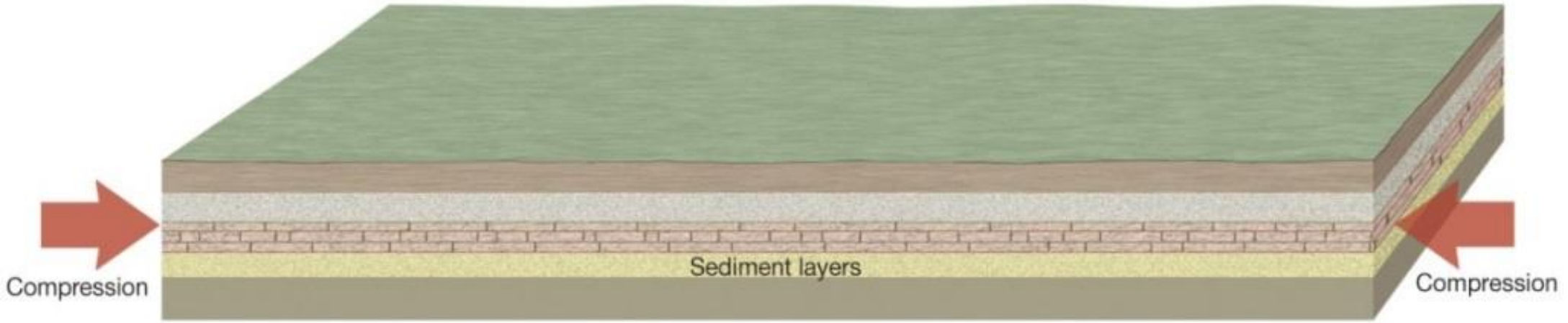
- A general term that refers to the deformation of Earth's crust and implies that the material is solid and not molten.
- Two types of diastrophic movements: **folding and faulting**.
- **Folding**—the bending of crustal rocks by compression and/or uplift (with great pressure being applied for long periods).
- **Faulting**—the breaking apart of crustal rocks with accompanying displacement
- (vertical, horizontal, or both).
- clear-cut.

Stress and Strain

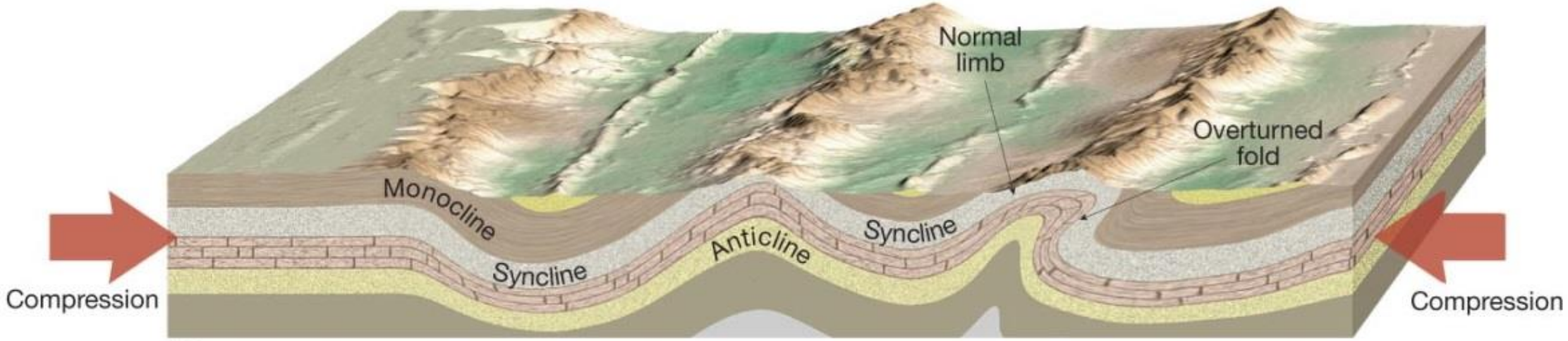


Folding

- Can vary from centimeters to tens of kilometers, from simple and symmetrical forms to complex, asymmetrical.
- Two types
  - **Anticline**/upfold—a simple symmetrical upfold; **produces ridges**
  - **Syncline/downfold**— a simple downfold; **produces valleys**



(a)



(b)

Faulting

Occurs when rock breaks accompanied by displacement (*movement of the crust on one or both sides of the break*)

Fault zones: zones of weakness in the crust that allow faults to occur

- Can vary in time (slow or sudden) and in size (centimeter to 20 or 30 feet [in sudden slippage] up to hundreds of kilometers horizontally and tens of kilometers vertically [over millions of years]).

Earthquakes usually but not exclusively associated with faults.

Fault lines: intersection of fault zone with Earth surface

Earthquakes:

- When there is a sudden displacement of a fault, shock waves produce vibrations we call earthquakes.
- Earthquake waves:
  - **Seismic waves** are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. They are the energy that travels through the earth and is recorded on seismographs.
  - There are several different kinds of seismic waves, and they all move in different ways. The two main types of waves are **body waves** and **surface waves**.
  - Body-waves include: Primary-waves (P-waves) and Secondary-waves (S-waves)
  - Surface waves: Love-waves (L-waves) and Rayleigh-waves (R-waves)

Earthquake Waves

- Primary or P waves are the fastest moving waves, moving through Earth (***solid rocks and fluids like water or the liquid layers of the earth***) like sound waves, alternately compressing and relaxing the material they pass through.
- the first to 'arrive' at a seismic station.

http://www.geo.mtu.edu/UPSeis/images/P-wave_animation.gif

- Also known as **compressional waves**, because of the ***pushing and pulling*** they do.
- Particles move in the same direction that P waves do, which is the direction that the energy is traveling, and is sometimes called the '**direction of wave propagation**'.

Earthquake Waves

- Secondary or S waves are slower moving, passing through the body of Earth, producing both strong ***side-to-side and up-and-down "shearing"*** motion.

- S waves are slower than a P waves and **can only move through solid rock**, **not through any liquid medium**.

- S waves move rock particles up and down, or ***side-to-side***--perpindicular to the direction that the wave is traveling in (the direction of wave propagation)

http://www.geo.mtu.edu/UPSeis/images/S-wave_animation.gif

Earthquake Waves

Surface Waves: do not travel through Earth like P and S waves do, but only travel across surface, immediately after S waves, and produce strong side-to-side and up-and-down so-called rolling motion.

Though they arrive after body waves, it is surface waves that are almost entirely responsible for the damage and destruction associated with earthquakes.

Earthquake Waves

- ***Love waves***: (named after A.E.H. Love, a British mathematician) the fastest surface wave and moves the ground from side-to-side.

- Confined to the surface of the crust, Love waves produce entirely **horizontal** motion.

http://www.geo.mtu.edu/UPSeis/images/Love_animation.gif

Earthquake Waves

- **Rayleigh waves**: A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down, and side-to-side (vertical mainly) in the same direction that the wave is moving.

- Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

http://www.geo.mtu.edu/UPSeis/images/Rayleigh_animation.gif

Exercise 2: Minerals and Rocks

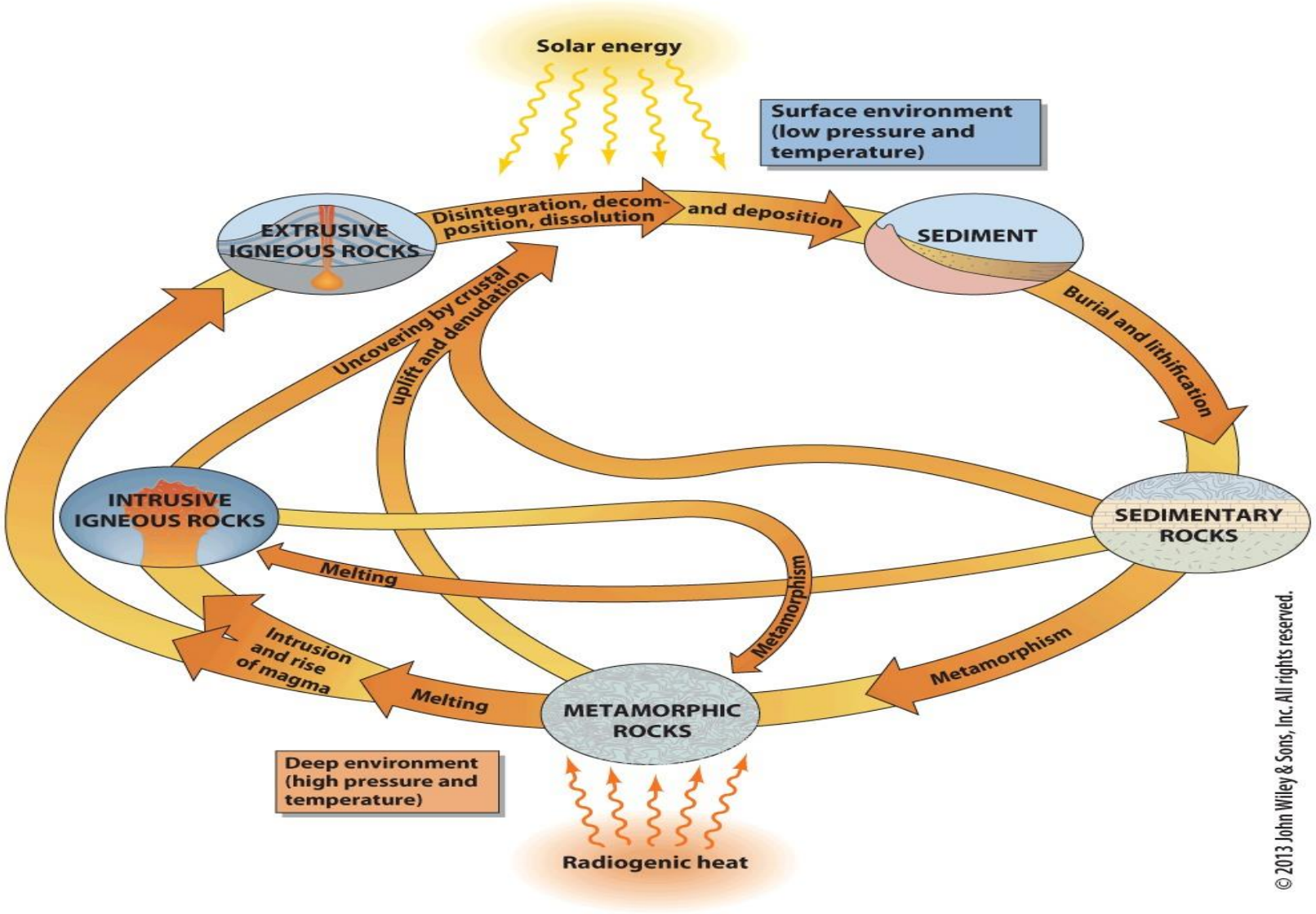
- A one/two-page summary of the Rock Cycle (about 400-500 words) that includes a definition of the term rock, the three main types of rocks and how they connect through the cycle. Include images, if necessary.

Types of rocks

There are three types of rocks:

- Igneous Rocks
- Sedimentary Rocks
- Metamorphic Rocks

The Cycle Of Rock Change



This ends our discussion of “From Below”

Next Time:
From Below To Above: The Atmosphere