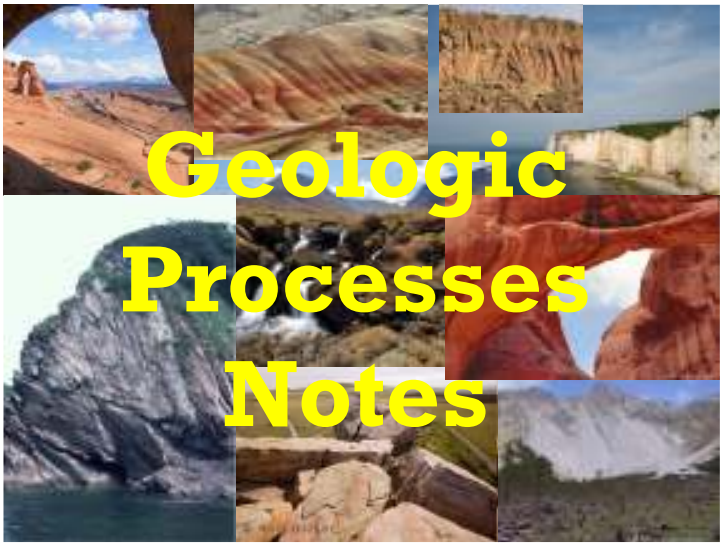
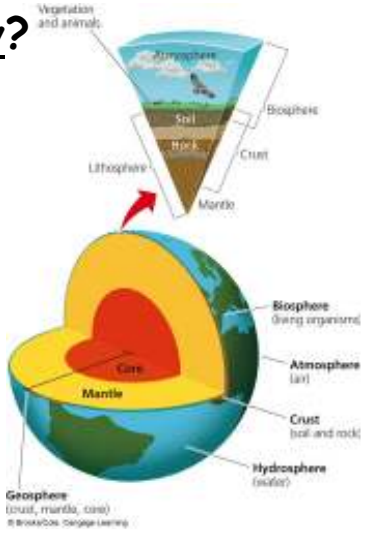


Geologic Processes Notes

What is geology?

- The study of dynamic processes occurring on the earth's surface & in its interior.
- As primitive earth cooled over eons, its interior separated into 3 concentric zones: the core, the mantle, & the crust.



CORE

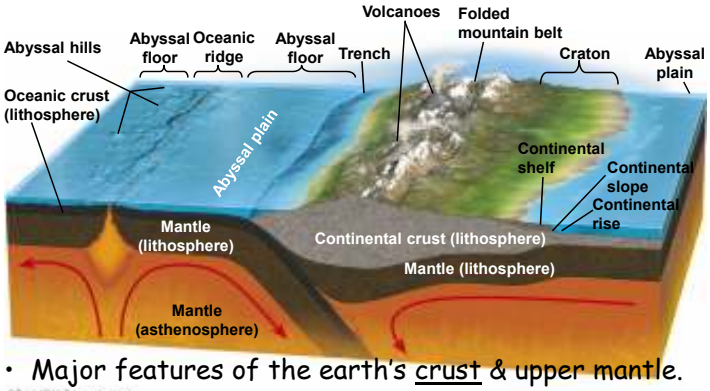
- Earth's innermost zone.
- Extremely hot.
- Has a solid inner core believed to consist of an iron-nickel alloy surrounded by an outer liquid core of molten material (magma = molten rock).

MANTLE

- A thick zone surrounding the core.
- Most of it is solid rock—the rigid outermost part.
- Contains the asthenosphere: a zone of hot, partly melted rock that flows; can be deformed like soft plastic.

CRUST

- Outermost and thinnest zone.
- Consists of:
  - continental crust: lies beneath the continents including the continental shelves extending into the oceans.
  - oceanic crust: underlies the ocean basins and makes up 71% of the earth's crust.

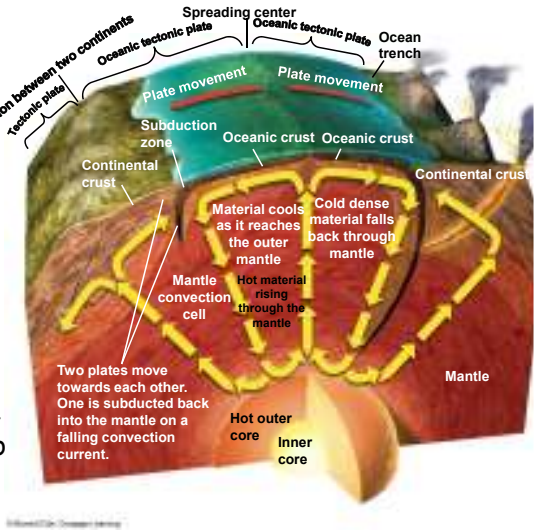


- Major features of the earth's crust & upper mantle.
- The *lithosphere*, composed of the crust & outermost mantle, is rigid & brittle.
- The *asthenosphere* (zone in the mantle) can be deformed by heat and pressure.

The earth beneath your feet is moving.

- Convections cells or currents: move large volumes of rock & heat in loops within the mantle like gigantic conveyer belts.
  - These flows of energy & heated materials cause huge rigid plates to move slowly on top of the denser mantle.

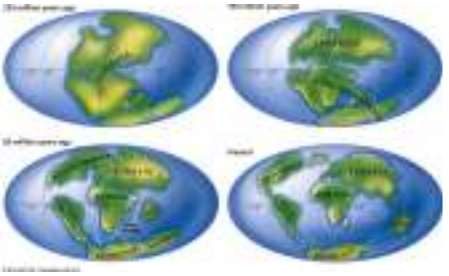
The earth's crust is made up of a mosaic of huge rigid plates, called tectonic plates, which move very slowly across the asthenosphere in response to forces in the mantle.



TECTONIC PLATES

- Gigantic rigid plates.
- Composed of the continental & oceanic crust and the rigid outermost part of the mantle: the lithosphere.
- World's largest & slowest-moving surfboards.
  - Their typical speed is about the rate at which fingernails grow.

TECTONIC PLATES



- You ride on one of these plates your whole life without noticing!!!
- Throughout earth's 4.6 billion year history, continents have split apart & joined as tectonic plates drifted 1,000s of kilometers back & forth atop the mantle.

Rock & fossil evidence indicates that 200-250 million yrs ago, all continents were locked together in a super continent—Pangaea.

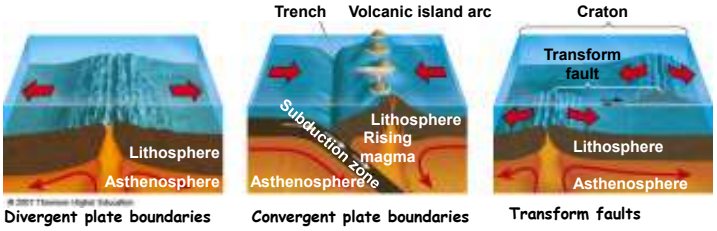
About 180 million yrs ago, Pangaea began splitting apart as tectonic plates separated, eventually resulting in today's locations of the continents.

Most geologic activity takes place at the boundaries between plates as they separate, collide, or slide past one another.

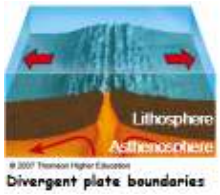
This causes:

- Mountains & oceanic trenches to form.
- Earthquakes to shake parts of the crust.
- Volcanoes to erupt.
- Continents to form or separate.

The Earth's Major Tectonic Plates:
What plate are you riding on?



- The extremely slow movements of these plates cause them to grind into one another at ***convergent plate boundaries***, move apart from one another at ***divergent plate boundaries***, and slide past each other at ***transform plate boundaries***.



Divergent Plates

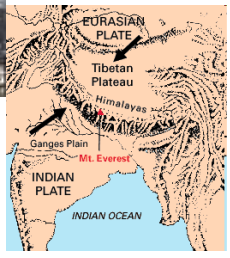
- When oceanic plates move apart in opposite directions & magma flows up through the resulting cracks.
- Creates oceanic ridges where some have higher peaks & deeper canyons than the continents have.

- When an oceanic plate collides with a continental plate.
- The continental plate rides up over the denser oceanic plate & pushes it down into the mantle in a process called subduction.
- Over time, the subducted plate melts & then rises again to the earth's surface as magma.
- A trench forms at the boundary between the 2 converging plates.

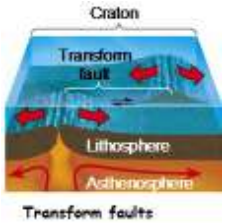
Convergent Plates

Convergent Plates

The Himalayan mountain range b/w China & India includes Mount Everest, the world's highest mountain peak.



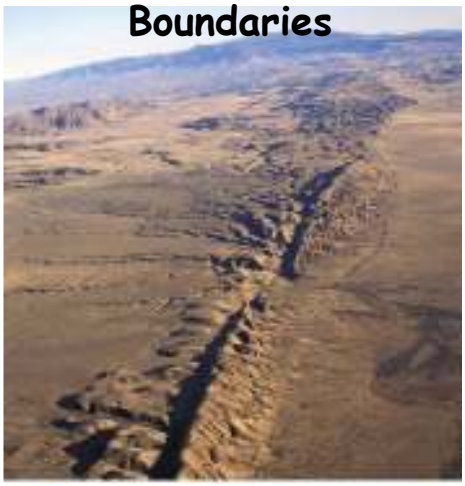
- **When 2 continents carried on converging plates ram into each other, they push up mountain ranges, such as the Himalayas, along the collision boundary.**



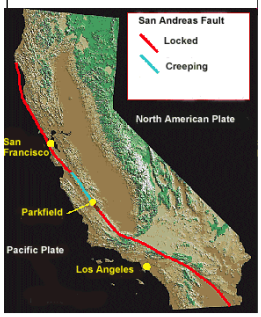
Transform Faults
(opposite but parallel directions)

- When plates slide & grind past one another along a fracture (fault) in the lithosphere.
- Most are located on the ocean floor, but a few are found on land.
  - The North American Plate & the Pacific Plate slide past each other along California's San Andreas fault.

Transform Fault Plate Boundaries



•The San Andreas Fault, which runs along almost the full length of CA, is responsible for earthquakes of various magnitudes.



Importance of Geologic Processes

- Plate movement adds new land at boundaries and produces mountains, trenches, earthquakes, and volcanoes.
- Tectonic plate movement plays a big part in the recycling of the planet's crust over geological time, which has helped form mineral deposits & promote and sustain life.
- As continents separated, populations became geographically & reproductively isolated, and speciation occurred.

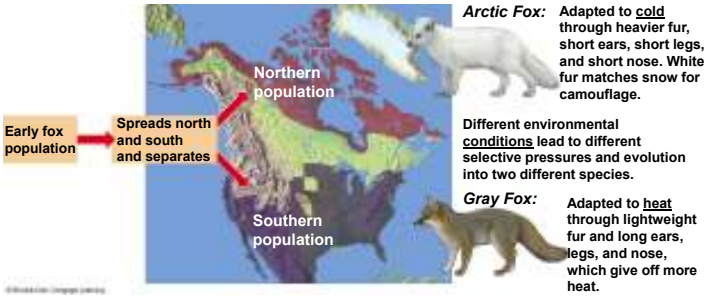
Importance of Geologic Processes

- Plate movements & volcanic eruptions have led to climate change that shifted wildlife habitats, wiped out large numbers of species, & created opportunities for the evolution of new species.
  - The locations of continents and oceanic basins influence climate.
  - The movement of continents have allowed species to move.

SPECIATION

- New species can arise when members of a population become isolated for a long period of time.
  - Their genetic makeup changes, preventing them from producing fertile offspring with the original population; they become two different sets of species.

Geographic Isolation...



- …can lead to reproductive isolation, divergence of gene pools, and speciation.

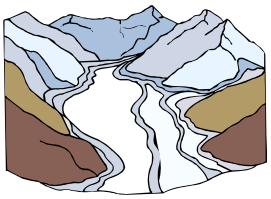
Some parts of the earth's surface build up & some wear down.

- *Internal geologic processes:* generated by heat from earth's interior, typically build up the earth's surface in the form of continental & oceanic crust.
- *External geologic processes:* driven by energy from the sun (mostly in the form of flowing water and wind) & influenced by gravity; tend to wear down the earth's surface & move matter from one place to another.

External Geologic Processes

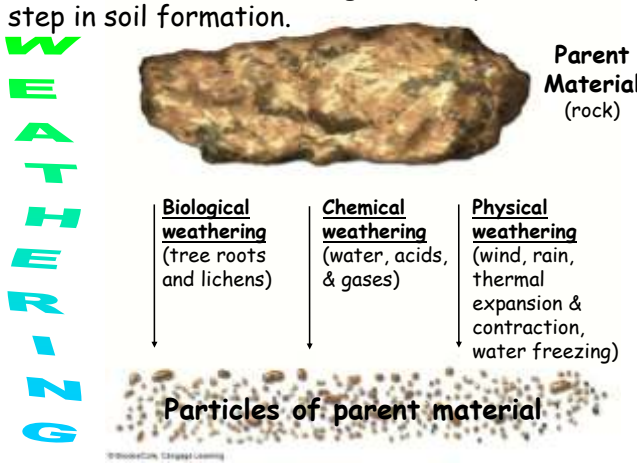
- ***Weathering:*** physical, chemical, & biological processes that break down rocks into smaller particles that help build soil.
- ***Erosion:*** material is dissolved, loosened, or worn away from one part of the earth's surface & deposited elsewhere.
  - Flowing streams & rain cause most erosion.
  - Wind also blows particles of soil from one area to another.
  - Human activities—those that destroy vegetation that holds soil in place—accelerate the process.
  - Glaciers (slowly flowing bodies of ice) cause erosion.

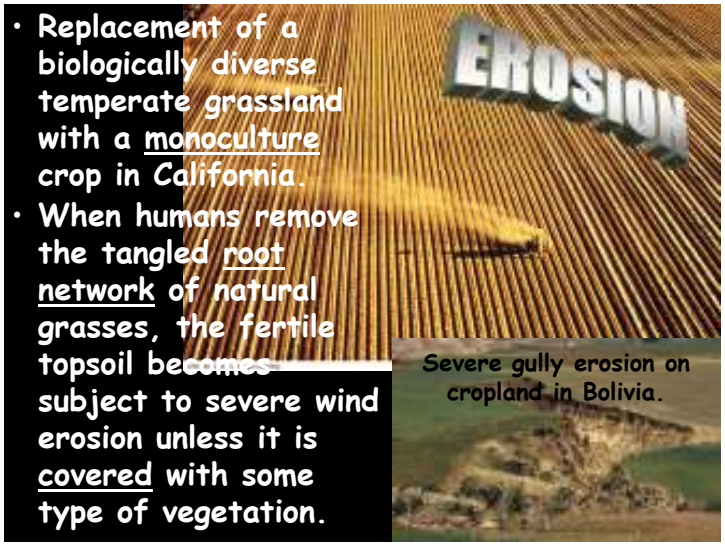
Glaciers



- Move slowly down a mountainside or over a wide area under the influence of gravity.
- Rock is pulled along or plucked out of the land surface.
  - During the last ice age (ended 10,000 years ago) ice sheets covered vast areas of North America, Europe, & Asia.
  - The Great Lakes formed during this period as retreating glaciers gouged (hollowed) out huge basins, & as the climate warmed, the glaciers melted filling in these depressions.

Biological, chemical, & physical processes weather or convert rock into smaller fragments & particles; the 1st step in soil formation.





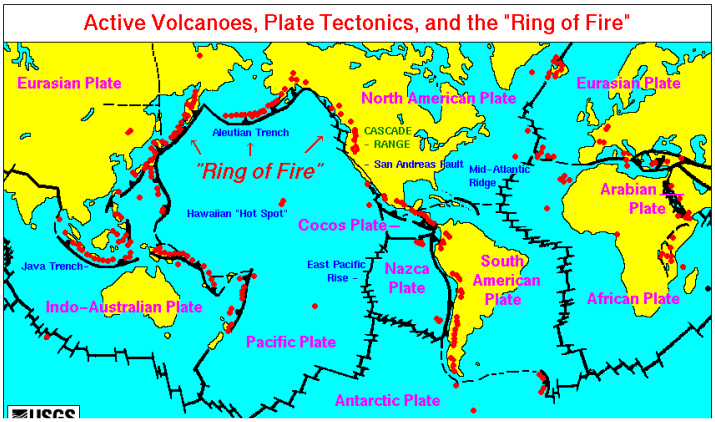
- Replacement of a biologically diverse temperate grassland with a monoculture crop in California.
- When humans remove the tangled root network of natural grasses, the fertile topsoil becomes subject to severe wind erosion unless it is covered with some type of vegetation.

Severe gully erosion on cropland in Bolivia.

- Tropical deforestation in Thailand.
- The clearing of trees that absorb carbon dioxide increases global warming.
- It also dehydrates the soil by exposing it to sunlight.
- The dry topsoil blows away, which prevents the reestablishment of a forest in this area.

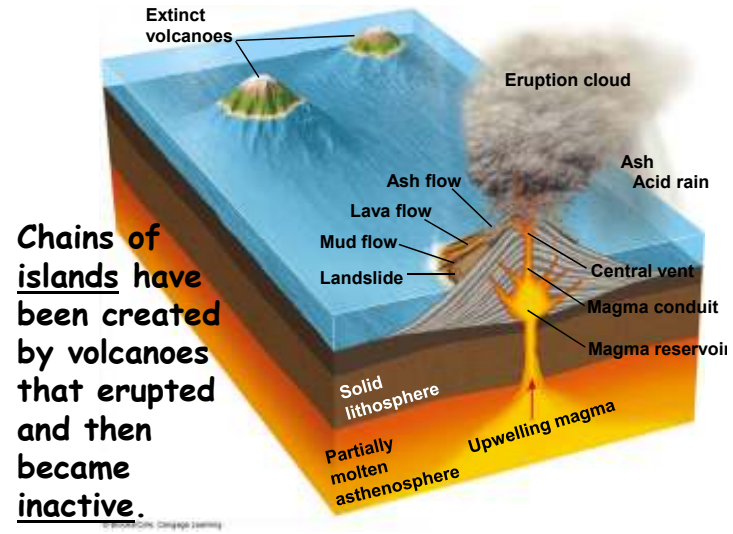
Pacific Plate

- Largest plate off the coast of CA.
- Volcanoes & earthquakes occur here.
- Location of the "**Ring of Fire**".



ACTIVE VOLCANOES

- Where magma reaches earth's surface (lava) through a fissure (central vent).
- Forms when one tectonic plate slides under or moves away from another plate.
- Releases debris into the environment: lava rock, ash, liquid lava, & gases (water vapor, carbon dioxide, & sulfur dioxide).
- Concentrated along plate boundaries.



Chains of islands have been created by volcanoes that erupted and then became inactive.

Mount Pinatubo: cooled the planet

- Largest volcanic eruption during 20th century; occurred in 1991.
- Killed several hundred people in the Philippines.
- Ejected enough material into the atmosphere to reduce incoming solar energy & **cool** the earth's average temperature for 15 months!

Mount Pinatubo

- http://videos.howstuffworks.com/discovery/7169-1991-mount-pinatubo-erruption-video.htm

Mount St. Helens, WA

- Worst volcanic disaster in U.S. history.
- Erupted May 18, 1980.
- 57 people & large #s of wildlife were killed.
- Large areas of forests were obliterated.
  - Ecological succession has restored some vegetation.

Benefits of Volcanic Activity

- Creates outstanding scenery.
  - Majestic mountains
  - Some lakes (Crater Lake in OR)
- Highly fertile soils are produced by the weathering of lava.

Crater Lake

The collapse of Mt. Mazama created Crater Lake.

To reduce loss of human life…

- Use historical records & geologic measurements to identify high-risk areas.
- Use monitoring devices that warn us when volcanoes are likely to erupt.
- Develop evacuation plans for volcanic-prone areas.

EARTHQUAKES

- Forces inside the mantle & along the surface push, deform, & stress rocks.
- When a fault forms, or when there is abrupt movement on an existing fault, energy that has accumulated is released in the form of vibrations = seismic waves.
- Seismic waves move in all directions through the surrounding rock.

EARTHQUAKES

- Most occur at boundaries of tectonic plates.
- Effects include shaking & sometimes permanent vertical or horizontal displacement of the ground.
- Serious consequences for people, buildings, bridges, freeway overpasses, dams, & pipelines.

Focus

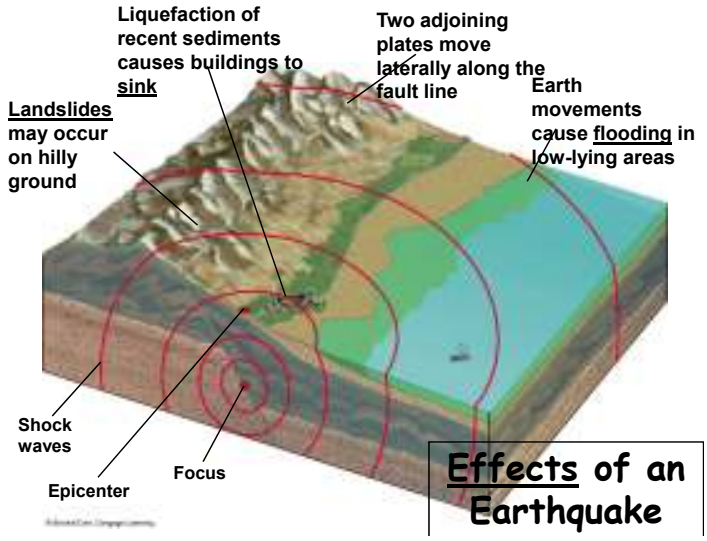
- Place where an earthquake begins.

Epicenter

- Located on the earth's surface directly above the focus.

Shock Waves

- Seismic waves.
- Energy released to relieve earth's internal stress.
- Move outward from the focus like ripples in a pool of water.



Effects of an Earthquake

How do scientists measure the severity of an earthquake?

- A seismograph records the magnitude (measure of ground shaking) of its seismic waves as indicated by the amplitude (size) of the shock waves.
- They use the Richter scale: each unit has amplitude 10 times greater than the next smaller unit.
  - A magnitude 5.0 earthquake would result in 10 times more ground motion than a magnitude 4.0 earthquake.

Using the Richter scale, compare the amount of ground movement from a magnitude 7.0 quake to that of a 5.0 quake.

- 7.0 → 6.0 → 5.0
- 10 x 10
- A magnitude 7.0 earthquake is **100 times** greater than that of a magnitude 5.0 earthquake.

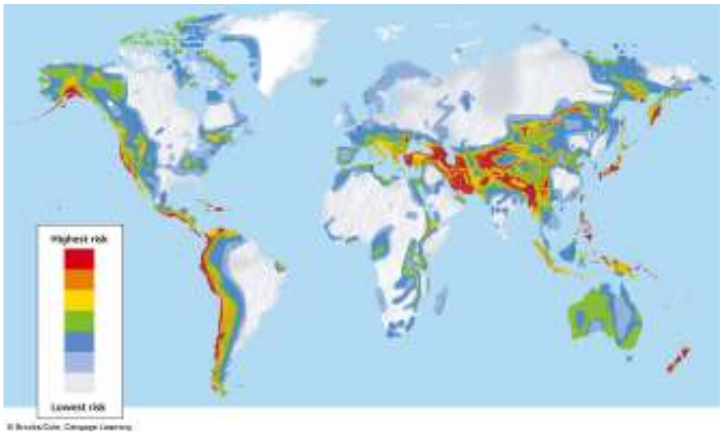
Seismologists Rate Earthquakes:

- Insignificant = less than 4.0
- Minor = 4.0 to 4.9
- Damaging = 5.0 to 5.9
- Destructive = 6.0 to 6.9
- Major = 7.0 to 7.9
- Great = over 8.0
  - Largest recorded land earthquake in Chile on May 22, 1960 & measured 9.5 on the Richter scale.

Areas of greatest earthquake (seismic) risk in the United States.

- Earthquakes often release aftershocks that gradually decrease in frequency over time—up to several months.
- Some are preceded by foreshocks.

Areas of greatest earthquake (seismic) risk in the world.



To reduce loss of life & property…

- Examine historical records & geologic measurements to locate active fault zones.
- Map high-risk areas & establish building codes to regulate placement & design of buildings in such areas.
  - Engineers can design homes, buildings, bridges, & freeways to be more earthquake resistant ▶ more expensive.
- People can evaluate the risk & decide where to live.

Tsunami

- Series of large waves generated when part of the ocean floor suddenly rises or drops.
- Caused when faults in the ocean floor move up or down as a result of a large underwater earthquake, or sometimes by a volcanic eruption.
- Sometimes called tidal waves—but they have nothing to do with the tides.

Tsunamis can…

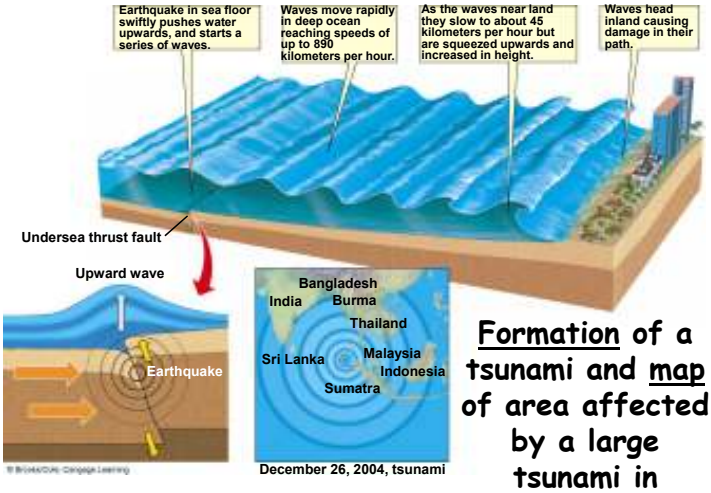
- Travel far across the ocean at speeds as high as jet planes.
- Hit a coast as a series of towering walls of water that can level buildings.
- Be detected through a network of ocean buoys to provide some degree of early warning.

Tsunamis can…

- Also be detected through use of a pressure recorder on the ocean floor.
  - Measures changes in water pressure as tsunami waves pass over it.
  - These data are relayed to a weather buoy, which then transmits the data via satellite to tsunami emergency warning centers.

December 2004:

- Largest loss of life from a tsunami when a ***great*** underwater earthquake (9.5 on Richter scale) occurred in the Indian Ocean.
  - Generated waves as high as 100 feet (31 meters).
  - Killed 228,000 people.
  - Devastated coastal areas of Indonesia, Thailand, Sri Lanka, South India, & eastern Africa.
  - No buoys or pressure gauges were in place in the Indian Ocean to provide early warning.



Formation of a tsunami and map of area affected by a large tsunami in December 2004.

Role of Marine Ecosystems:

- Satellite observations & ground studies pointed to the role that coral reefs & mangrove forests played in reducing the death toll & destruction from the 2004 tsunami.
  - Intact mangrove forests in parts of Thailand helped to protect buildings & people from the force of huge waves.
  - However, extensive damage & high deaths in India's Tamus state attributed to the clearing of a third of its coastal mangrove forests in recent decades.
  - In Sri Lanka, some of the greatest damage occurred where illegal coral mining & reef damage had caused severe beach erosion.

The Earth's crust consists mostly of minerals and rocks

- **Mineral:** an element or inorganic compound that occurs naturally in the earth's crust as a solid with a regular internal crystalline structure.
  - Au (gold), Ag (silver), C (diamonds), NaCl (salt), SiO_2 (quartzite)
- **Rock:** a solid combination of one or more minerals found in the earth's crust.
  - Limestone, granite, feldspar, quartz, mica

Rock is placed in 3 classes based on the way it forms:

- Sedimentary
- Igneous
- Metamorphic

Sedimentary Rock

- Forms from sediments of dead plant & animal remains & existing rocks that are weathered & eroded into tiny particles that are transported by water, wind, or gravity to downstream, downwind, downhill, or underwater sites.
- Sediments are deposited in layers that accumulate over time & increase the weight & pressure on underlying layers.

Examples of Sedimentary Rock:

- *sandstone* & *shale* (formed from pressure created by deposited layers of mostly sand)
- *dolomite* & *limestone* (formed form the compacted shells, skeletons, & other remains of dead organisms)
- *lignite* (brown coal) & *bituminous* (soft coal) (derived from compacted plant remains).
- Gemstones include jasper, malachite, opal, and zircon.

Igneous Rock

- Forms below or on the earth's surface when magma wells up from the earth's upper mantle or deep crust & then cools and hardens.
- Forms the bulk of the earth's crust; often covered by sedimentary rocks & soil.

Examples of Igneous Rock:

- *Intrusive Igneous Rocks* – formed from the solidification of magma below ground.
  - *granite*
- *Extrusive Igneous Rocks* – formed from the solidification of lava above ground.
  - *lava rock, pumice, basalt, obsidian*
- Gemstones formed are diamond, tourmaline, garnet, emerald, amethyst, topaz.

Metamorphic Rock

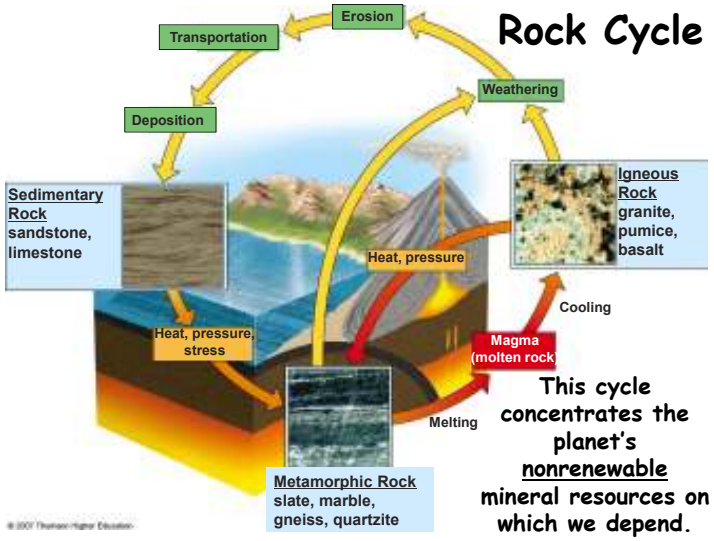
- When preexisting rock is subjected to high temperatures (which may cause it to partially melt), high pressures, chemically active fluids, or a combination of these agents.
- These forces transform a rock by reshaping its internal crystalline structure along with its physical properties & appearance.
- Location – deep within the earth.

Examples of Metamorphic Rock:

- *anthracite* (a form of coal = hard coal)
- *slate* (formed when shale & mudstone are heated)
- *marble* (produced when limestone is exposed to heat and pressure)
- Gemstones include the turquoise, ruby, sapphire, zircon.

Rock Cycle

- Interaction of physical & chemical processes that change rocks from one type to another.
- Largest & the slowest of the earth's BGC cycles.
  - Takes millions of years.
  - Rocks are broken down, eroded, crushed, heated, melted, fused together by heat & pressure, cooled, &/or recrystallized within the mantle & in the crust.



Oxygen

- The most abundant *element* in Earth's crust.

Nitrogen

- The most abundant *element* in the Earth's atmosphere.

Iron

- The most abundant *metal* in the Earth's core.

Aluminum

- Most abundant *metal* in the Earth's crust, (and the third most abundant element therein, after oxygen and silicon).
- The element commercially extracted from bauxite ore.

Don't Forget to...

Do this for HW!

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