Topic 9 – Dynamic Crust

Vocabulary

Asthenosphere – partly liquid layer of Earth's mantle just below the crust.

Continental crust – part of the Earth's crust (lithosphere) that makes up the continents. Made of mostly granite.

Convergent plate – boundary between two colliding pates

Crust – outermost portion of Earth's solid layer, also called **lithosphere**

Divergent plate – part of the Earth's crust moving apart often at mid ocean ridges.

Earthquake – shaking of Earth's crust due to release of energy in the crust

Epicenter – point on the surface above the focus. Origin of an earthquake

Faulted – rock layers that are offset

Focus – the place where an earthquake originates in the crust

Folded – bent rock layers

Hot spot – region of volcanic activity on the interior of plates, may also be at plate boundaries

Inner core – inner most portion of Earth, thought to be solid

Island arc – islands chains associated with convergent plate boundaries, Aluetian islands

Lithosphere – the Earth's crust

Mantle – solid portion between crust and outer core

Mid – ocean ridge – a mountain range at the bottom of oceans along divergent zones

Moho – the interface between Earth's crust and the mantle

Ocean crust – portion of Earth's crust below the oceans, made of basalt

Ocean trench – deep narrow zone along subduction zones

Original horizontality – states that rock layers are deposited horizontal until they harden

Outer core – zone of Earth between mantle and inner core, liquid material

Plate – tectonic plate, mass of crust that moves around Earth's solid surface

P-wave – earthquake waves that travel through solid and liquid, also called primary waves

Seismic wave – waves given off by an earthquake

Subduction – plate at convergent boundary dives below another plate and is destroyed

S-wave – travel through Earth in solid material only

Transform plate – boundary where plates slide past each other, San Andreas Fault

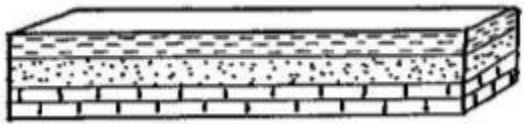
Tsunami – very large ocean wave generated by an under ocean earthquake, very destructive

Uplifted – crust raised from tectonic forces, mountains formed

Volcano – a mountain composed of igneous rock material

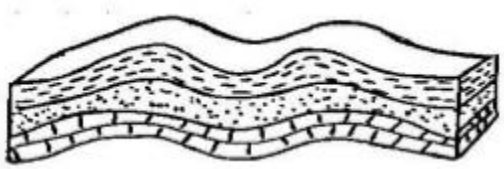
Overview of Topic

I. Crustal Changes
   a. Original horizontality
      - Rock layers are deposited horizontal, parallel to Earth's surface.
      - Remain horizontal until forces on earth alter them



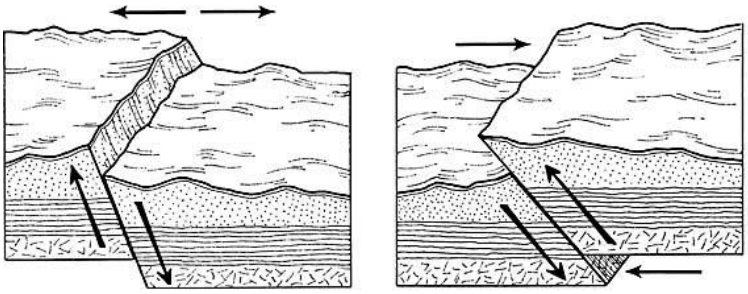
Layers of rock are in layers

   b. Folded
      - Rocks are bent by earth's tectonic forces (crustal movement)



Forces push rock layers to make them bend

   c. Faulting
      - Rocks layers break due to fast movement of earth's crust.



Forces can be stretching or pushing to make a fault.

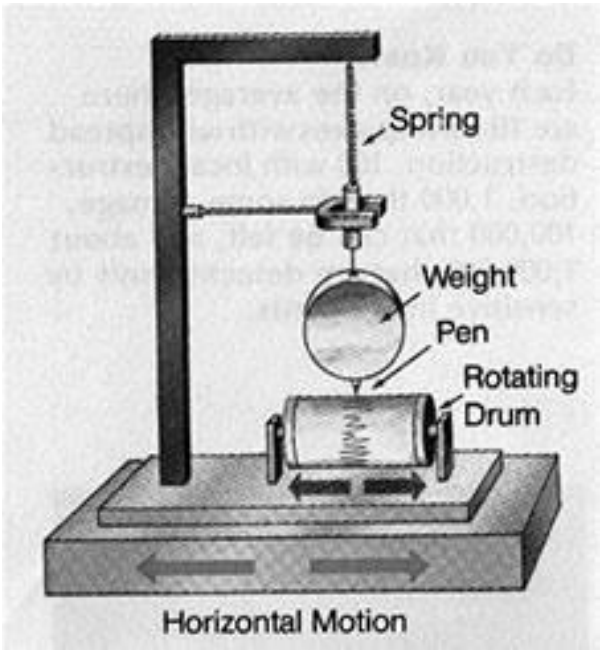
Bedrock layers are often depicted in the above images. The symbols have meaning and indicate the type of rock material. Often it refers to the sedimentary rock layers. Page 7 of the ESRT shows in the table Scheme for Sedimentary Rock Identification the symbol in the far right column. Each rock layers has its own name and symbol.

Mountain ranges are the result of crustal changes. As the earth's crust moves plate (crust) bumps into each other crustal create mountains. The event creating mountain ranges is called an **OROGENY.** Page 8 and 9 of the ESRT shows the orogeny events that have occurred in Earth's history.

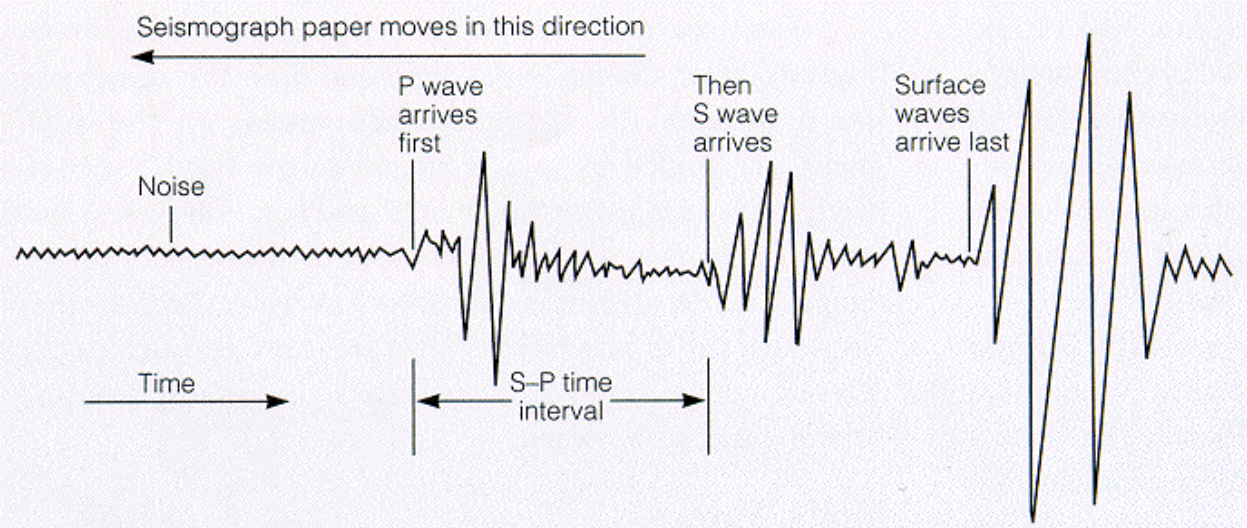
II. Earthquakes and Volcanoes

Page 5 of the ESRT shows Tectonic plates and at the edges there are zones of great activity. Along the margin of the Pacific Ocean is the "Ring of Fire". Many earthquakes and volcanoes are located long the Ring of Fire. This is not the only region of high tectonic activity. Any plate boundary can tectonic activity. Earthquakes can happen anywhere on earth, but more commonly along plate boundaries.

a. Earthquake waves
   - There are 2 types used to locate the origin of an Earthquake.
   - Detected on a seismograph, which is a device that vibrates as the earthquake waves arrive. It detects intensity and duration. Detects both primary and secondary waves.

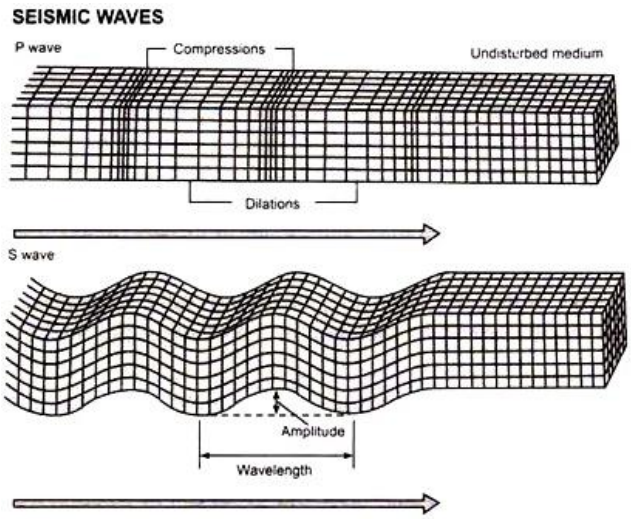


   - A seismogram is the paper that created using a seismograph. Notice the P – wave and the S- wave? The duration is measured in min : sec on the paper.



1. P – waves or primary wave
    - Compression waves
    - Travel the fastest
    - Travel through both solid and liquid portions of the Earth interior.

2. S – waves or secondary waves
    - Shear waves
    - Travel slower
    - Travel only through solid portion of Earth's interior.



3. Finding origin times.
    - Earthquakes travel in minutes and seconds, NOT hours.
    - Remember there are 60 seconds in a minute, makes borrowing easy.

Example 1)

$$\begin{array}{r} 12 \text{ min } 20\ sec \\ \underline{-\ 8 \text{ min } 10\ sec} \end{array}$$

This is a straight forward. If the seconds are smaller on the bottom then you can subtract.

- The answer is 4 min 10 sec

Example 2)

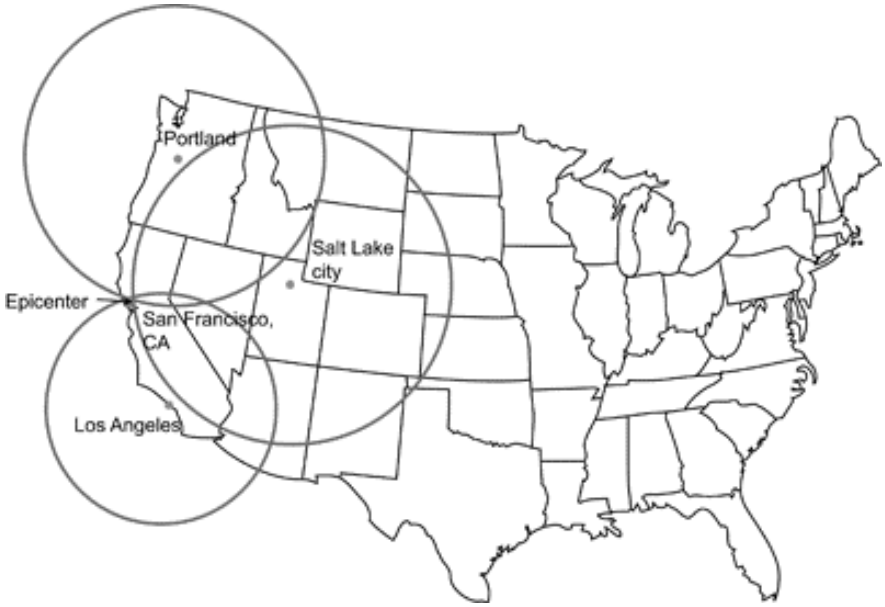
$$\begin{array}{r} 12 \text{ min } 05\ sec \\ \underline{-\ 5 \text{ min } 20\ sec} \end{array}$$

This is more difficult because you need to borrow. The number on the bottom is larger than the number on the top. You need to borrow 60 seconds of time from the minutes (1 min = 60 sec). Add 60 seconds to 05 seconds and you how have 65 sec, but remember to take away 1 min from the

$$\begin{array}{r} 11 \text{ min } 65\ sec \\ \underline{-\ 5 \text{ min } 20\ sec} \\ 6 \text{ min } 45\ sec \end{array}$$

- https://www.youtube.com/watch?v=GcqSj43evE0

4. Location of an epicenter
    - Need at least three location on Earth that detected and measured the earthquake.
    - Intersection of the three circles (radii) from the seismogram readings is your epicenter.
    - The larger the radius, the further the seismic (P and S waves) traveled from the epicenter.



- https://www.youtube.com/watch?v=TBss68oBmmk

5. Page 11 ESRT to find travel times and distances
   (Video above shows how to use)

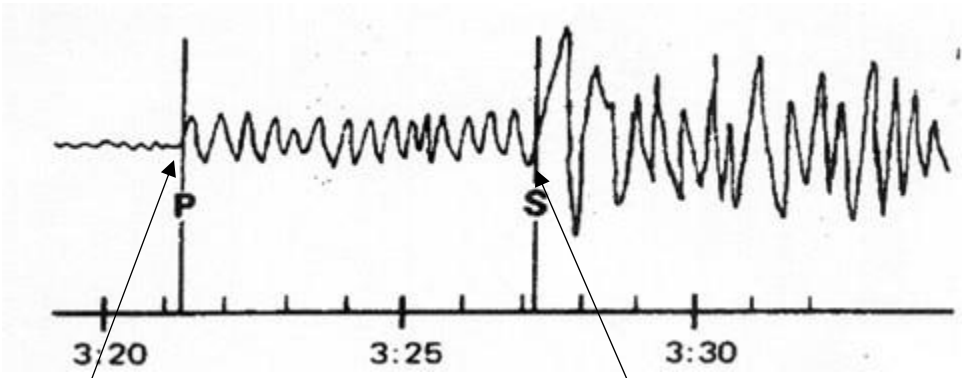
- Y-axis is in minutes and seconds.
    - ✓ Each tick mark is 20seconds on this chart, others are different

- X-axis is the distance in kilometers
    - ✓ This scale is in scientific notation
    - ✓ Each tick mark is 200 km on this chart, others are different

6. Locating the Epicenter of an Earthquake

<u>Part I: Finding the distance to the epicenter</u>

- **Step 1:** Determine the difference in arrival time for the P-wave, and the S-wave.



P – wave (3:21) S - wave (3:27)This seismograph is in clock time.

Formula to use:

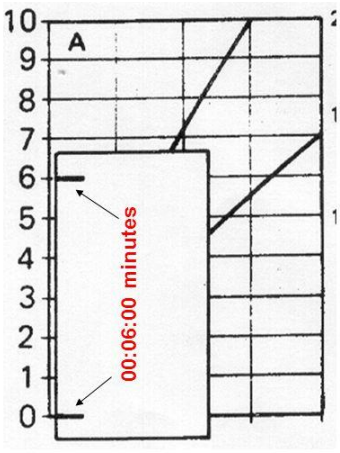
S wave – P wave = Travel Time or Time Lag

$$\begin{array}{r} \mathbf{3:27} \\ -\ \mathbf{3:21} \\ \hline \mathbf{0:06} \end{array}$$

We found the travel time is 6 minutes, which means a distance in kilometer we need to find using page 11 of the ESRT

Locating the Epicenter of an Earthquake

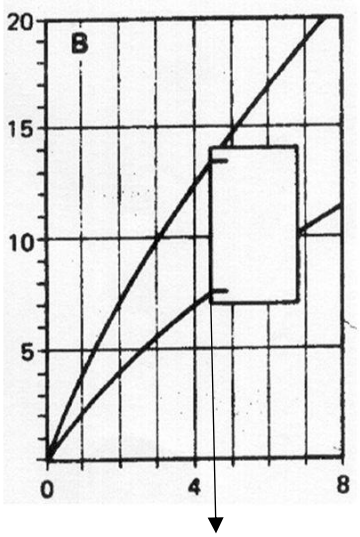
Part I: Finding the distance to the epicenter



- **Step 2:**
  - Take out your ESRT. Open to the Travel Time Graph on page 11.
- **Step 3:**
  - Use the vertical scale (time) to mark off the difference in arrival time on a scrap sheet of paper.

Locating the Epicenter of an Earthquake

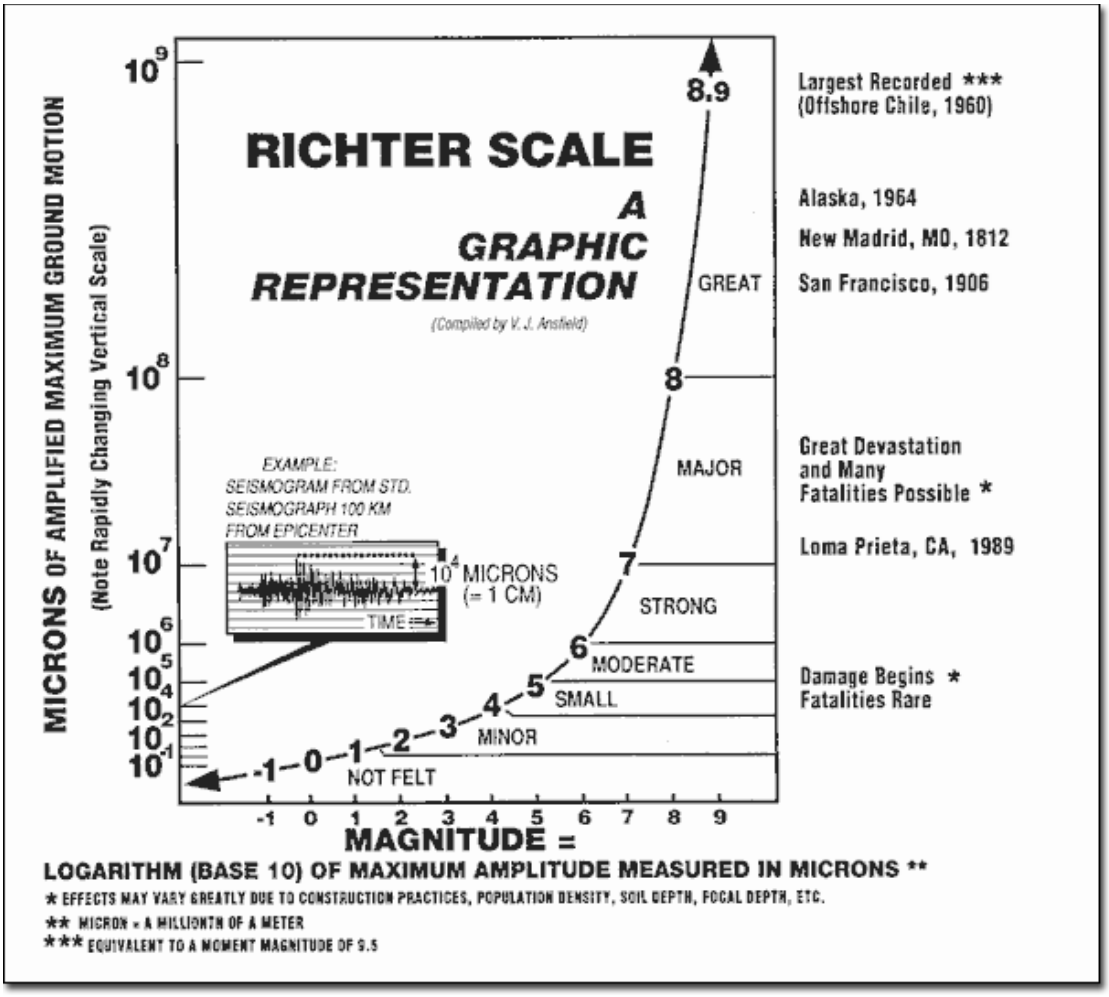
Part I: Finding the distance to the epicenter



- **Step 4:**
  - Make sure to keep your scrap paper **vertical**! Slide it along the curves until it lines up on each of the curves.
  - **Be very accurate!!!!!**

Where the spacing of 6 minutes is equal to the S and P line on the chart is where you stop moving the paper. Follow the edge of the paper to the X – axis (see arrow). This is the distance to the epicenter. The distance to the epicenter is about 4,500 km. That is how far away the earthquake epicenter was from the recording station. You need 2 more locations to pinpoint the exact location.

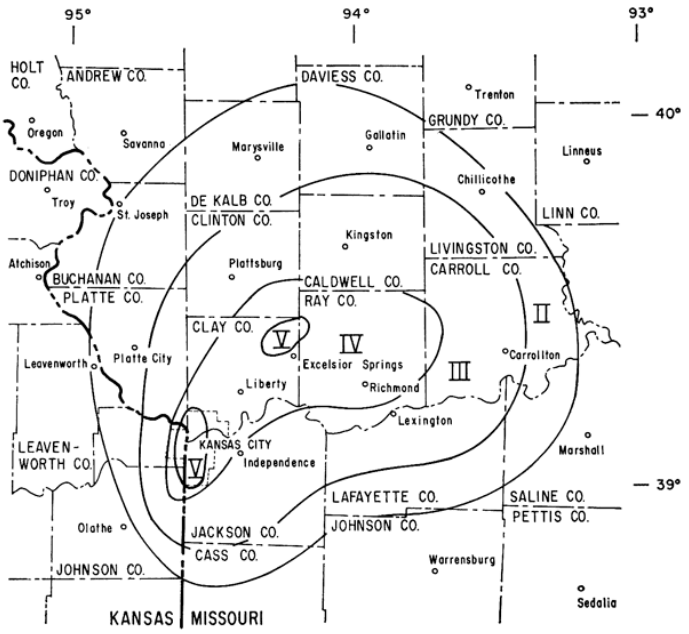
7. Earthquake Magnitudes
    - Richter
        - Measures energy of the earthquake



- Mercalli
    - Measures visible damage

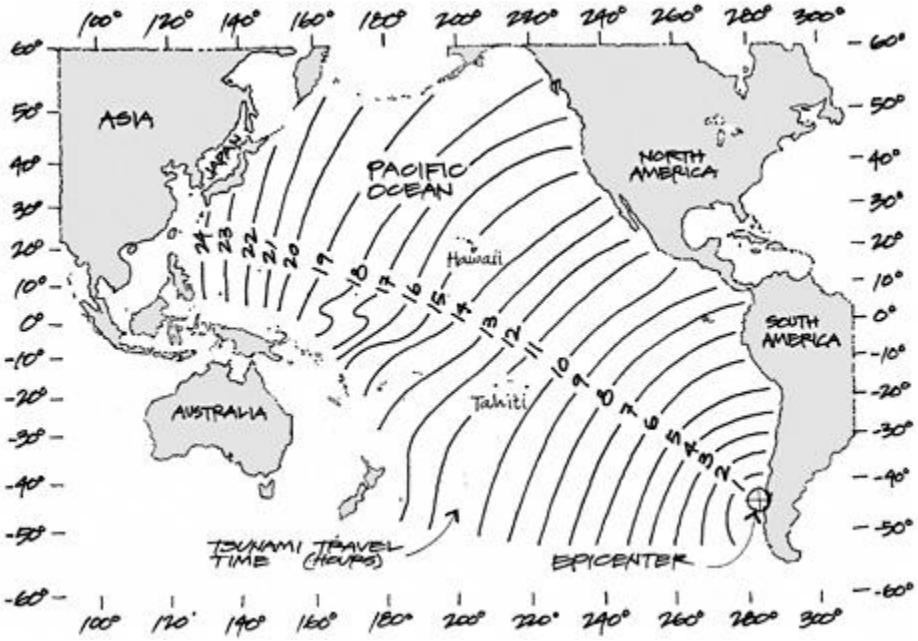
Level of Earthquake	Instrumental	Detected only by seismographs
I	Instrumental	Detected only by seismographs
II.	Feeble	Noticed only by sensitive people.
III	Slight	Resembling vibrations caused by heavy traffic
IV	Moderate	Felt by people walking; rocking of free standing objects
V	Rather strong	Sleepers awakened and bells ring
VI	Strong	Trees sway, some damage from overturning and falling objects.
VII	Very strong	General alarm, cracking of walls
VIII	Destructive	Chimneys fall and there is some damage to buildings
IX	Ruinous	Ground begins to crack, houses begin to collapse and pipes reak.
X.	Disastrous	Ground badly cracked and many buildings are destroyed. There are some landslides
XI.	Very Disastrous	Few buildings remain standing; bridges and railways destroyed. water, gas, electricity and telephones out of action
XII	Catastrophic	Total destruction; objects are thrown into the air, much heaving, shaking and distortion of the ground.

- Mercalli map



- Greatest damage at Roman numeral V

8. Tsunamis
    - Results of an earthquake on the ocean floor
    - Wave of water 30 feet (10 meters) high hits shorelines
    - DEADLY!
    - Waves travel from epicenter and stop when they hit land

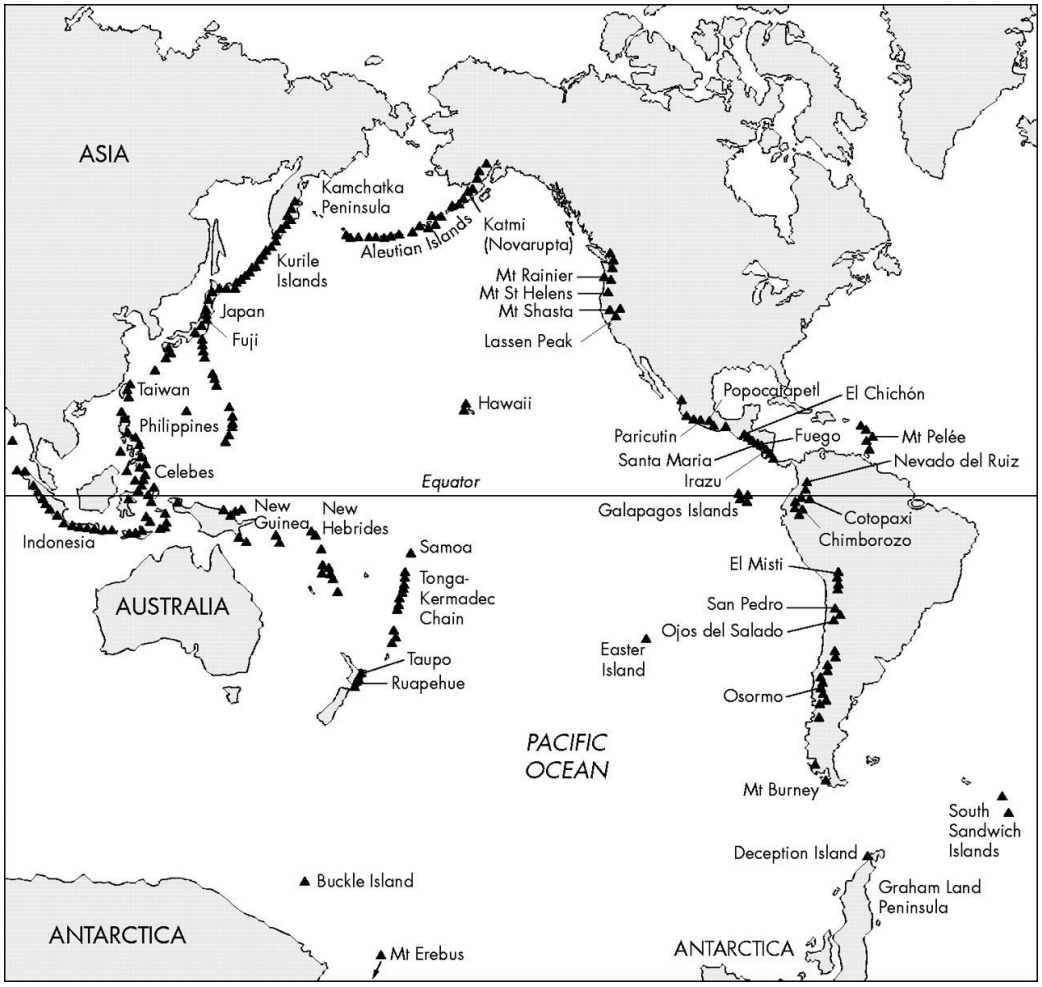


9. Emergency preparedness
    - Earthquakes
      Have drills
      Have emergency rations
      In building hide under desk or tables

    - Tsunamis
      Seek higher ground
      Emergency rations
      Have drills
      Build sea walls

10. Volcanoes
    - Mountains of ash, solidified magma and lava.
    - Destructive
    - Ash will bury all things in its path
    - Lava will burn

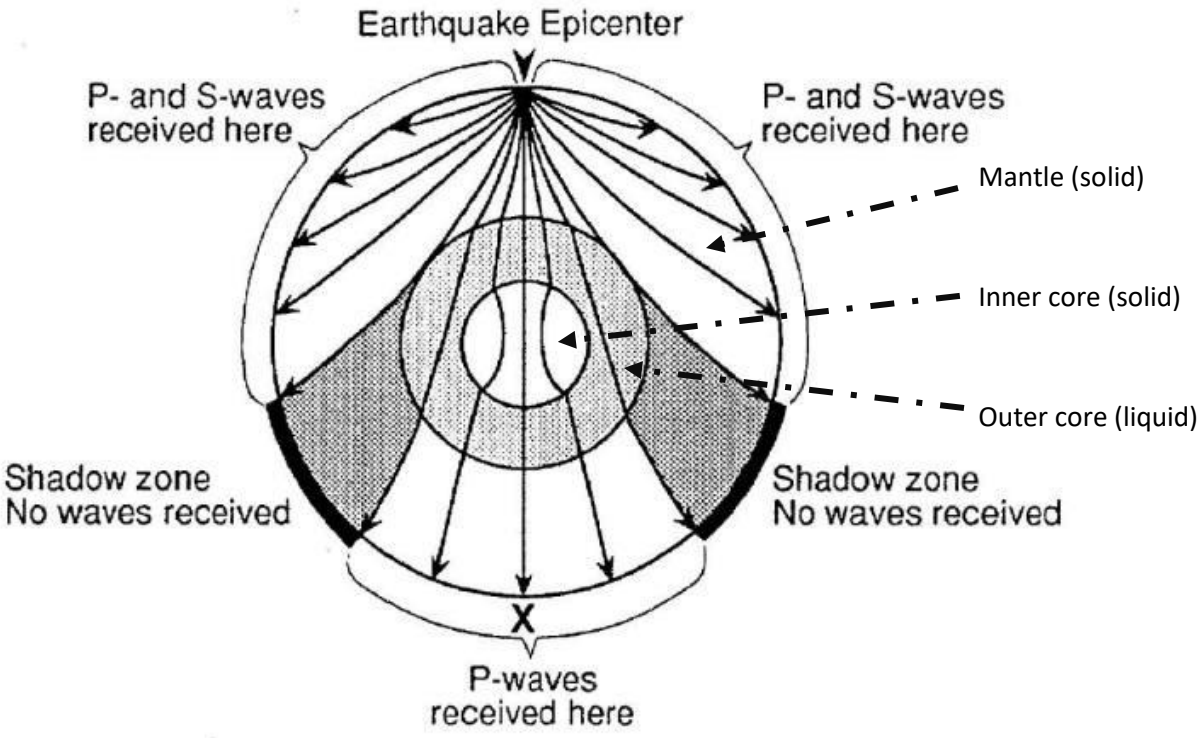
- Found along plate boundaries
    - ✓ Convergent
        - Where plates collide, come together
    - ✓ Divergent
        - Where plates move apart
- Ring of Fire
    - A ring of volcanoes and earthquake activity around the Pacific.
    - Page 5 ESRT



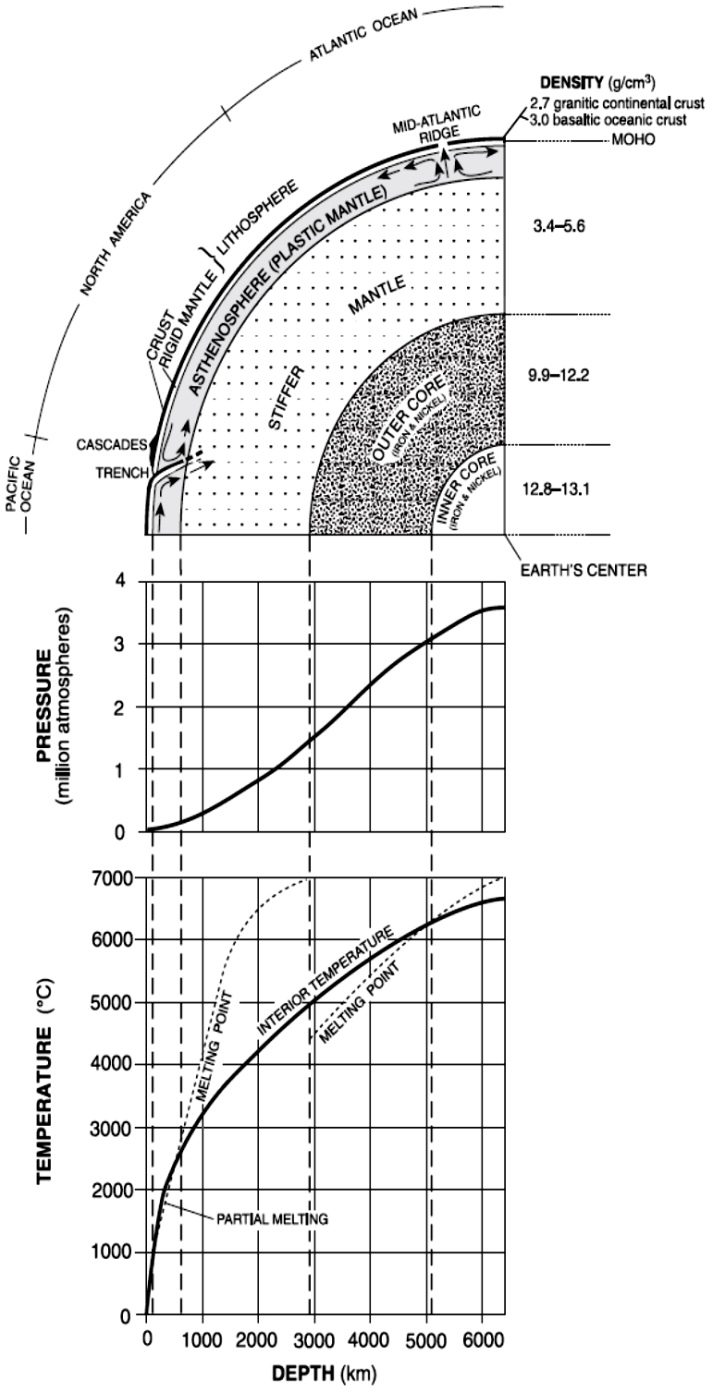
- Majority of the Ring of Fire is convergent plate boundaries.
- Mountain ranges are located on the continental margins that make up the Ring of Fire.

III. Earth's Interior

- Seismic waves determine the interior
- Waves behave differently in solid and liquid.
- Density of the Earth also changes the behavior of seismic waves



- Page 10 ESRT



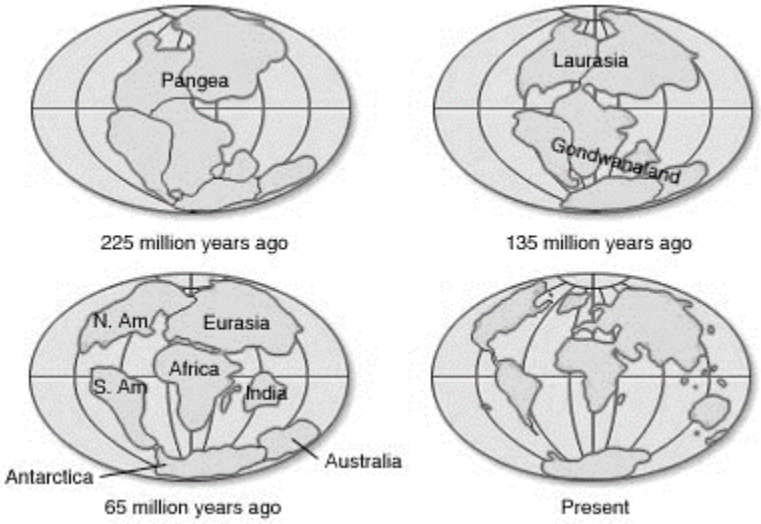
Upper part of table shows the layers of the Earth. There are lines separating the different layers. On the X-axis is the relative depth of the layers.

The middle part shows the change in pressure in the earth as you move from the surface to the interior. The dashed lines represent the boundaries between layers.

The bottom section shows temperature changes from the surface to the core. When the melting point is below the interior temperature then the layer is liquid. The dashed lines show the boundaries between layers.

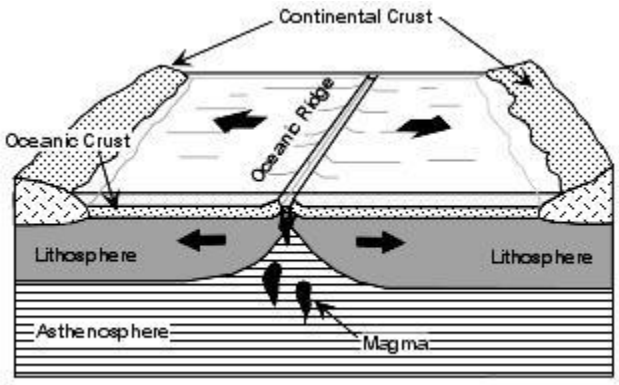
IV. Plate Boundaries

a. Changing Earth



Because the continents have been moving they collide and separate causing earthquakes and volcanoes. The mechanisms for Continental Drift is due to convection in the Earth's crust.

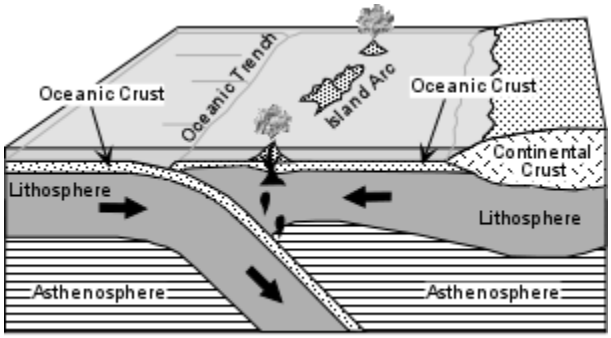
- Divergent boundary



Sea floor spreading, as magma rises the ocean crust pushes apart. The less dense continental crust floats on the denser ocean crust. In the asthenosphere is where convection, rising of hot magma occurs. The ocean floor is where most of the divergent boundaries are located.

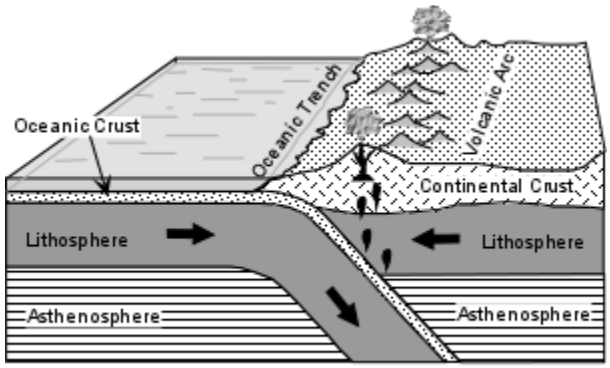
- Convergent boundary
    - Three types
    - The subduction zone is where one plate dives below another and the sub-ducting plate is destroyed.

        ✓ Ocean – Ocean



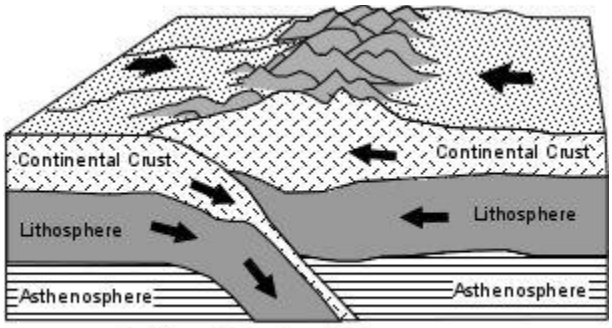
Ocean - Ocean Convergence

        ✓ Ocean – Continental



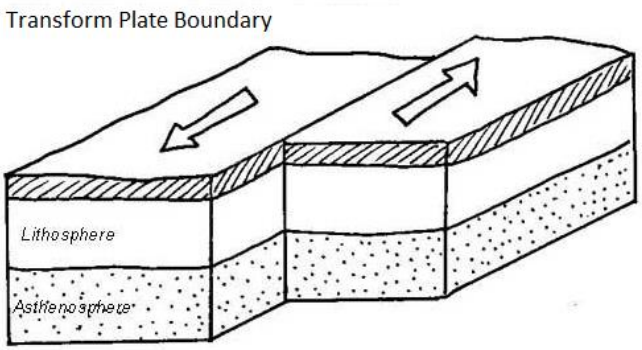
Ocean - Continent Convergence

✓ Continental- Continental



Continent- Continent Convergence

✓ Transform boundary

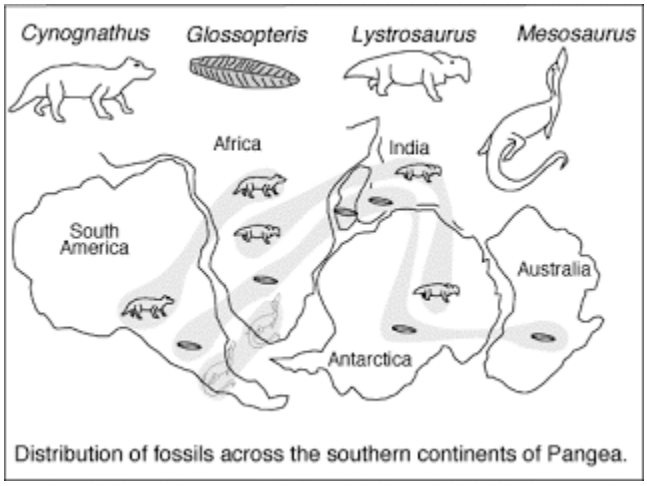


What is important in these diagrams is how the plates move. Arrows indicate the direction of movement.

b. Hot spots

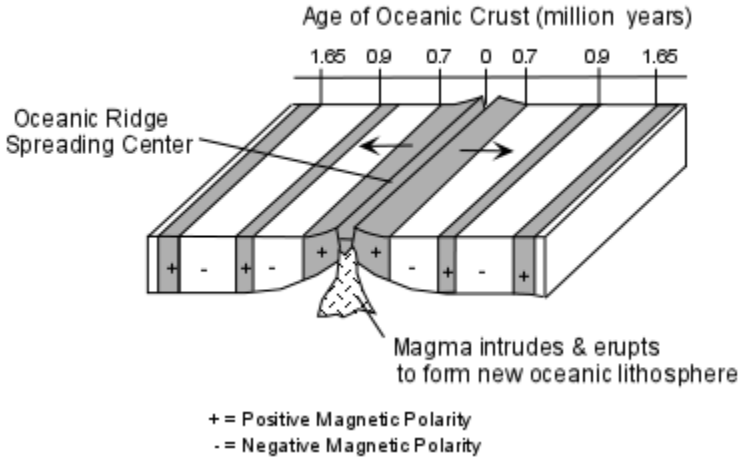
- Regions in Earth's crust where hot magma reaches the surface.
- Page 5 of the ESRT show several hot spots
- Can be located along plate boundaries or in the middle of a tectonic plate.

c. Past land masses
   - Continents have been moving from the convection of the Earth's interior.
   - Evidence of past continents are in rock formations, fossil evidence and glacial deposits.
   - The diagram below show fossilized organisms on several continents.



Distribution of fossils across the southern continents of Pangea.

d. Magnetic patterns on ocean floor
   - Magma contains iron and points to magnetic north. When the magma solidifies the iron points to current magnetic north
   - Magnetic reversals are evidence in ocean crust.



   - The width of the magnetic changes are the same on each side.
   - Magnetic reversal of Earth's poles have occurred in Earth's past and will occur again.

Earth Science Reference Table – (ESRT)

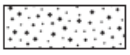
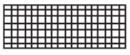
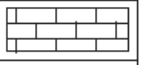
Pages from ESRT used in Topic 9.

Pages 5, 7, 10 and 11

Pages 5, 10 and 11 in the ESRT were outlined in the topic.

Page 7

Scheme for Sedimentary Rock Identification

INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	**Conglomerate**	
			Angular fragments	**Breccia**	
	Sand (0.006 to 0.2 cm)		Fine to coarse	**Sandstone**	
	Silt (0.0004 to 0.006 cm)		Very fine grain	**Siltstone**	
	Clay (less than 0.0004 cm)		Compact; may split easily	**Shale**	
CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Crystalline	Fine to coarse crystals	Halite	Crystals from chemical precipitates and evaporites	**Rock salt**	
		Gypsum		**Rock gypsum**	
		Dolomite		**Dolostone**	
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	**Limestone**	
Bioclastic		Carbon	Compacted plant remains	**Bituminous coal**	

Symbols for rock sedimentary rock are located to the far left. These symbols are used by geologists.

This topic is tested in the Regent Part D

https://www.youtube.com/watch?v=m087LO9bCX4 – lab practical Part D

Must know how to use:

- A compass
- Use page 11 of the ESRT
- Measure using included map scale
- Locate the epicenter where three circles cross