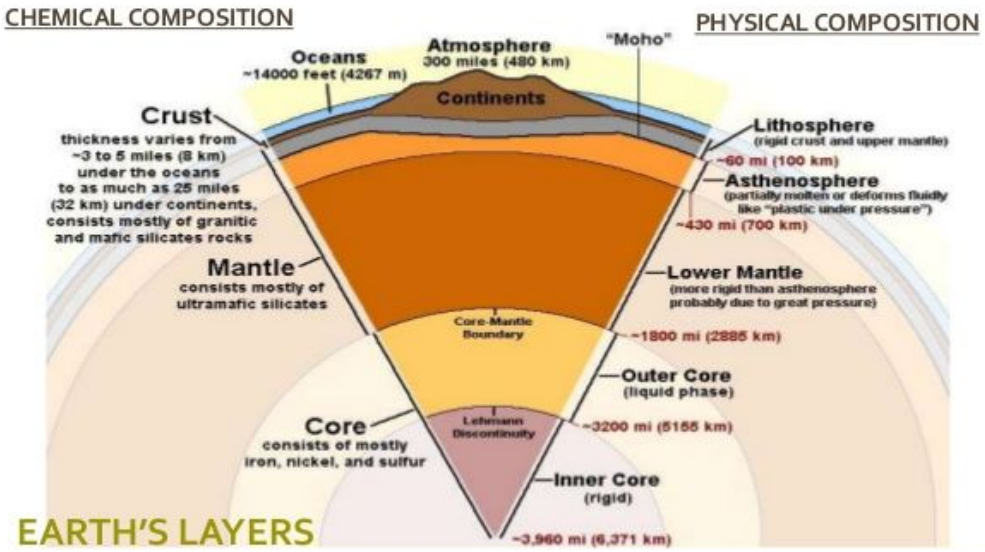
STUDY GUIDE (PACKET OUTLINE) - 3rd QUARTER EXAM 2018

Geologists have used THREE main types of evidence to learn about the Earth's Interior:

1. Rock samples from the crust and upper mantle (such as granite, basalt, peridotite, and iron) which have different densities
2. Indirect evidence from seismic waves that change speed and direction when they move through the layers of different densities
3. The composition and density of iron meteorites that is found in the core

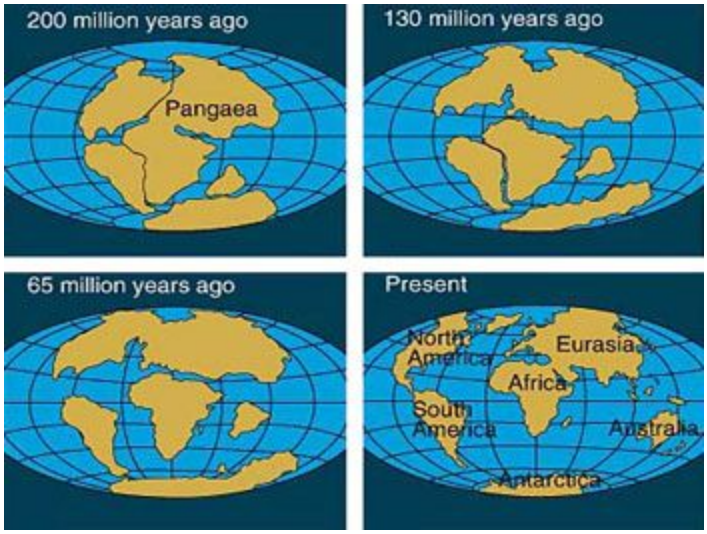
Layers of the Earth:

1. Lithosphere (surface layer)
    a. Combines the crust and upper mantle
    b. Broken into plates that continually move above the mantle
    c. Last dense and coolest layer
    d. Two types
        i. Oceanic Lithosphere - mostly Basalt, thinner and denser than continental
        ii. Continental Lithosphere - mostly Granite, thicker and less dense than oceanic
2. Asthenosphere
    a. Semi-solid, plastic-like layer under the Lithosphere that is able to flow
    b. Convection currents forming in this layer moves tectonic plates
    c. Denser and hotter than the Lithosphere
    d. Boundary between the Lithosphere and Asthenosphere is called the MOHO DISCONTINUITY (evidence - P waves speed up and bend)
3. Outer Core
    a. Only liquid layer (evidence - S waves cannot pass through this layer)
    b. Mostly iron and nickel
    c. Responsible for Earth's magnetic field
    d. Boundary between the mantle and outer core is called the GUTENBERG DISCONTINUITY
4. Inner Core
    a. Solid layer because of great pressure
    b. Mostly iron and nickel
    c. Most dense and hottest layer
    d. Heat is generated in this layer from radioactive decay



Continental Drift -

1. The theory of plate tectonics states that the lithosphere is broken into plates that have always been in constant motion. It is built upon the ideas of CONTINENTAL DRIFT put forth by **Alfred Wegener** in the early 1900s



2. **Evidence to support this theory** comes from a variety of sources:
    a. **The Mesosaurus fossil**, a fresh water reptile, that could not be dispersed by swimming were found on widely separated landmasses on South America and Africa
    b. **Rocks and Mountain ranges** from edges of continents
    c. **Glacial scrape marks** on land that is currently too close to the equator to sustain glaciers
    d. **Coal and tropical plant fossils** in Antarctica that indicate a change in the climate of that landmass as it moved around the globe
    e. **Age of rocks** on the seafloor, younger rocks being near the ridge or spreading centers between the plates.
    f. **Magnetic anomalies** along the ocean floor, showing periods of normal and reversed polarity

Sea floor Spreading -

1. Seafloor spreading occurs at a **divergent boundary**, where plates move apart
    a. Oceanic plates separate, exposing the mantle underneath. Magma rises from the asthenosphere, melts by decompression and flows in the gap between the plates. When it cools, it hardens creating new crust (basalt rock). The ocean floor pulls apart again, and the process repeats
    b. New rocks appear as a ridge or rift valley
    c. The seafloor grows or spreads
    d. The Mid-Atlantic ridge and East Pacific Rise is an example of a divergent boundary
    e. The ocean floor is very young, only about 180 million years old. Rocks on land are much older - 3.8 billion years old. Divergence allows for the creation of new seafloor.
    f. **Seafloor Spreading is the mechanism for Continental Drift.** When the seafloor moves outward from the ridge, they push the continents around. Convection currents under the lithosphere move the plates apart.
    g. Normal and Reverse Polarity

i. Earth's North and South poles act as a giant magnet. Compass needles point toward Earth's magnetic North
ii. As basaltic magma at a divergent boundary solidifies to form new rock, iron rich minerals in the magma align with Earth's magnetic field, indicating the direction of magnetic North at the time when the magma cooled. This forms a kind of magnetic signature, preserved in the basalt.
iii. The direction of Earth's magnetic field can be NORMAL (magnetic north is toward geographic north pole. This is also called a POSITIVE ANOMALY) or REVERSED (magnetic north is closer to the present day south pole. This is also called NEGATIVE ANOMALY)

h. Rocks formed at the divergent boundary form a band of rock with a single magnetic signature. When the plates separate, the new magma will form new rocks that may register a different signature or change in Earth's magnetic field.
i. ALL ROCKS THE SAME DISTANCE FROM THE MID-OCEAN RIDGE HAVE THE SAME AGE AND POLARITY (anomaly)

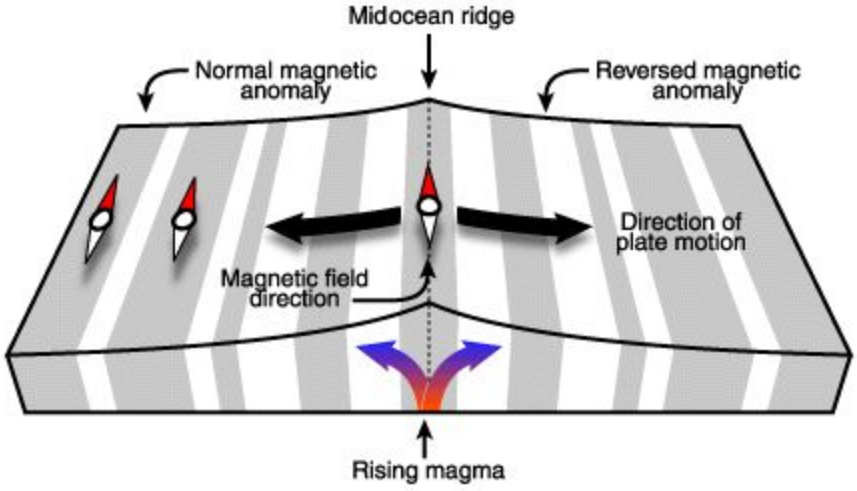
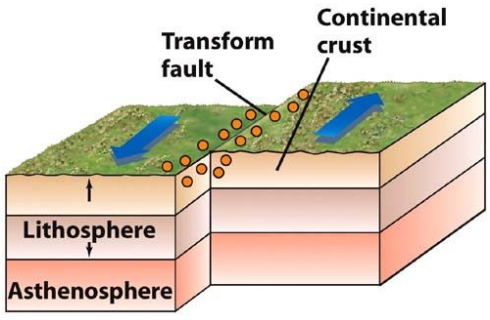


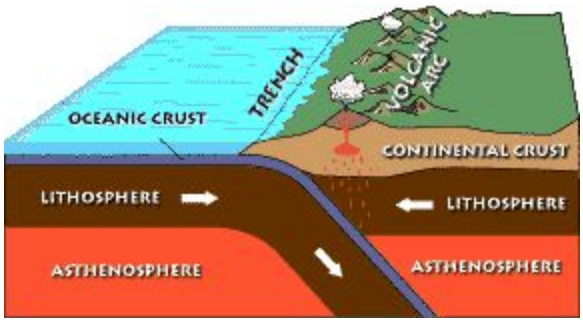
Plate Boundaries -

1. **Transform boundaries** are when plate slide past each other.
    a. No crust is formed or melted
    b. Faults or cracks in the rocks appear as the plates grind past each other
    c. Earthquakes are strongly associated with this boundary
    d. The San Andreas Fault is an example of a transform boundary

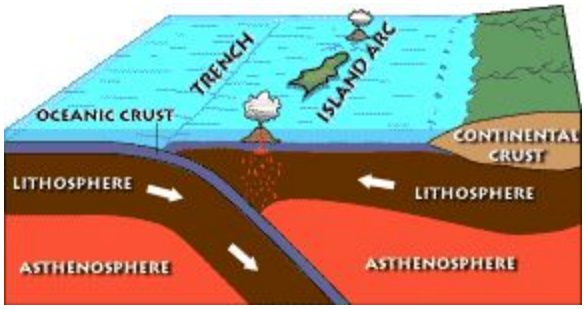


TRANSFORM FAULT BOUNDARY

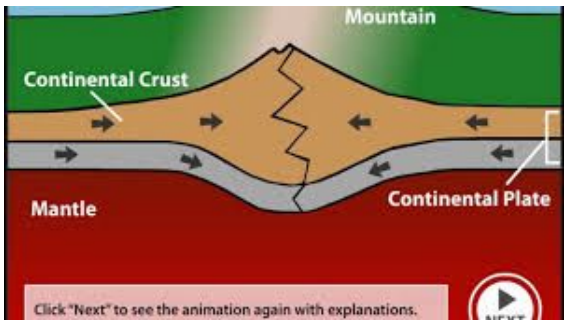
2. **Convergent Boundaries** are when plates move together or collide. There are 3 types:
    a. **Oceanic-Continental Convergence -**
        i. The oceanic plate subducts and is destroyed by melting, forming a volcanic arc on the continental plate and a deep sea trench in between the plates.
        ii. The more dense plate subducts
        iii. The Rocky Mountains is an example of this boundary



    b. **Oceanic-Oceanic Convergence -**
        i. One oceanic plate subducts and is melted, forming volcanic island arcs on the other oceanic plate and a deep sea trench in between the plates.
        ii. The more dense plate subducts
        iii. The Tonga Trench is an example of this boundary



    c. **Continental - Continental Convergence -**
        i. Neither plate subducts but folds and forms mountain ranges.
        ii. The Himalayas is an example of this boundary

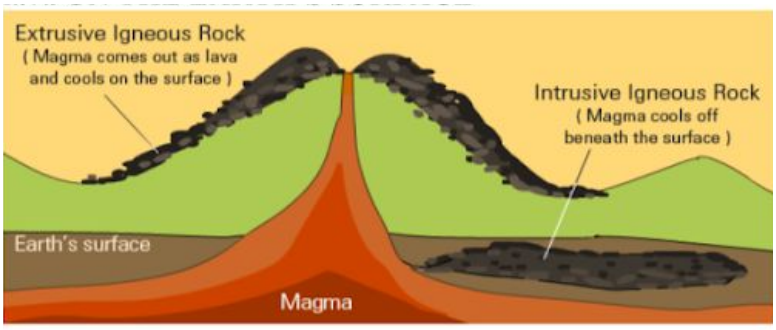


Rocks are solid mineral or mineral-like masses that occur naturally in the lithosphere and continuously change. Rocks are classified according the the way they were formed. There are three types of rocks: Igneous, Metamorphic, and Sedimentary.

Igneous Rocks -

Formed from the cooling and crystallization of magma UNDERGROUND or lava ON THE EARTH'S SURFACE. Igneous rocks are classified by TEXTURE and COMPOSITION.

1. TEXTURE:
    a. EXTRUSIVE - cooling of lava on Earth's surface
        i. Aphanitic texture are fine-grained (smooth) with small crystals due to fast cooling
        ii. Glassy texture looks like glass with very rapid cooling
        iii. Vesicular or porous texture has small air holes from air pockets in the lava
    b. INTRUSIVE - cooling of magma deep underground
        i. Phaneritic texture are very coarse (rough) grained with large crystals due to slow cooling
        ii. Pegmatitic texture are coarse grained with medium crystals due to slow cooling
2. COMPOSITION:
    a. Felsic composition (peanut butter viscosity magma) is mostly light colored minerals such as feldspar and silica
    b. Mafic composition (ketchup viscosity magma) is mostly dark colored minerals such as magnesium and iron



Metamorphic Rocks -

1. Metamorphic rocks are formed from HEAT and PRESSURE on existing rocks
2. The pressure can come from the weight of the rocks on top as rocks are DEEPLY buried, such as during subduction. The heat from the mantle partially melts the rocks and changes the minerals in them
3. Some metamorphic rocks are not formed at a subduction zone but are still heated when they are too close to magma moving up through a volcano
4. Minerals are FLATTENED and form banded layers due to pressure on the minerals
5. Layers may be bent and distorted if the pressure is uneven

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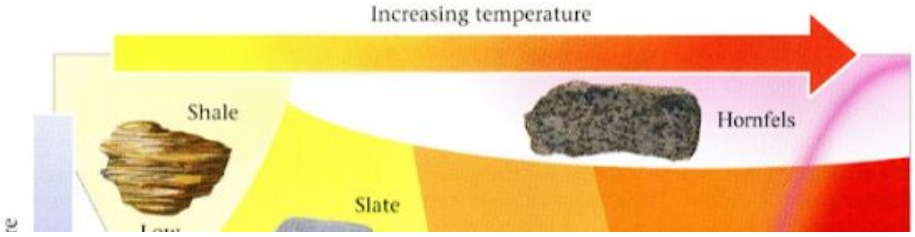


Igneous vs Sedimentary Rocks -

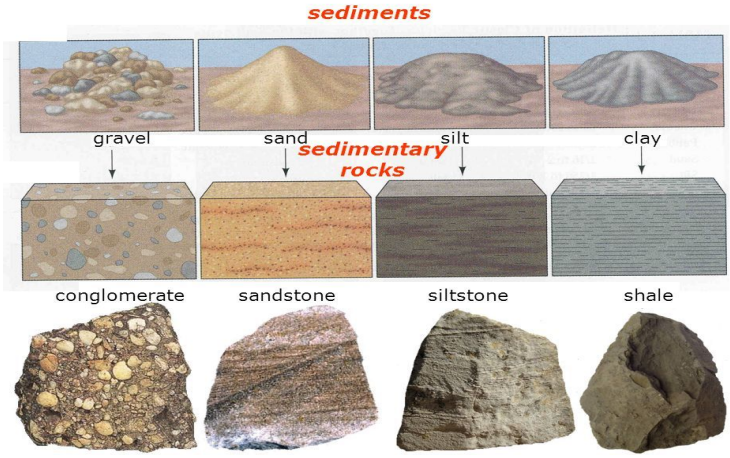
1. Igneous rocks are formed in the same location and therefore create crystals of INTERLOCKING angular grains. These grains do not have any air spaces and are more difficult to break
2. Sedimentary rocks are formed from different sized sediments from different locations and therefore create NON-INTERLOCKING rounded grains. These grains have air spaces and become easier to break apart

Sedimentary Rocks:

1. **Formed on EARTH'S SURFACE from sediments that settle out of water or air and become compacted and cemented together.**
2. The process takes place as a series of steps –
    a. **WEATHERING: Any process that breaks down rocks physically or chemically or both**
        i. Water in rivers or lakes or oceans break rocks into smaller fragments called sediments
        ii. Wind also scours rock with debris which breaks them into sediments
        iii. Ice expands the area between cracks in rocks further breaking them into fragments (**frost wedging)**
        iv. Gravity can cause boulders to hit against rocks chipping off smaller fragments
        v. Living things can break rock when they walk upon or grow in between them
        vi. Chemical weathering takes place when parts of rocks dissolve in water and leave other parts behind as fragments
        vii. Rocks that are harder will have a lower rate of weathering
        viii. **WEATHERING INCREASES THE SURFACE AREA OF ROCKS.** Increasing the surface area further accelerates the breakdown of rocks since more of the rock is exposed. SURFACE AREA = 2LW + 2LH + 2WH
        ix. Rocks get weathered to GRAVEL sized fragments, then to SAND, SILT and CLAY sized pieces. The smallest fragment is called CLAY.

b. **EROSION AND DEPOSITION: involves the movement or transport of rock fragments or sediments.**
   i. *Water, wind, ice and gravity are agents of erosion. They move sediments from one place to the next.* **Sediments become rounded as they are transported and tumbled in the water.**
   ii. Deposition occurs when the sediments are settled (deposited) in their new location. Sediments are usually deposited in the order of their density, with the densest dropped first and the least dense dropped last. **Gravel sized sediments settle first (the fastest); clay is deposited last, because it has the slowest settling rate**

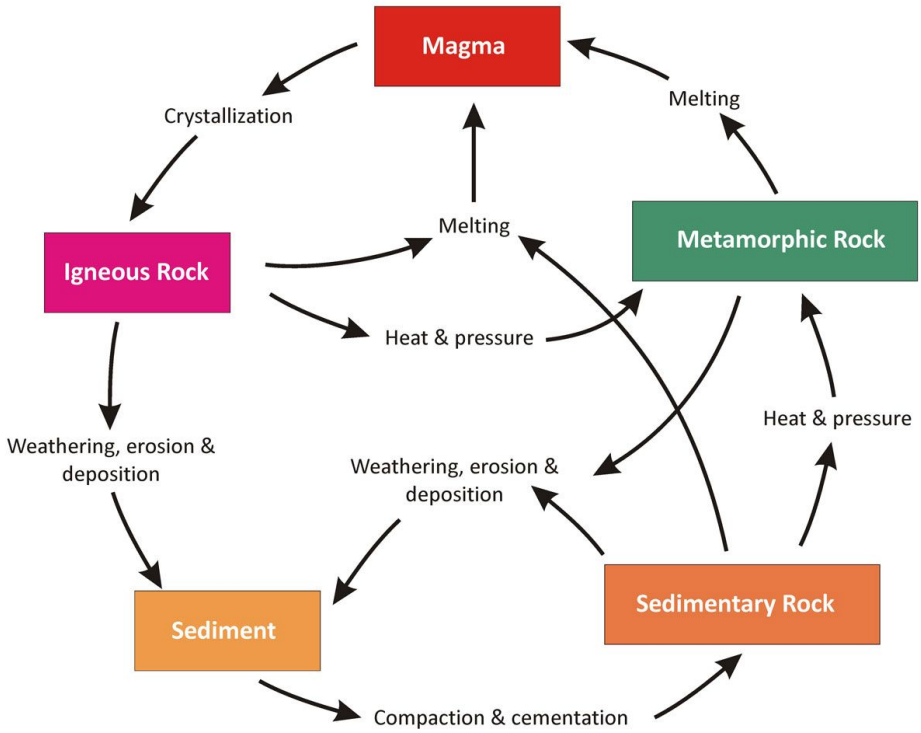
c. **COMPACTION AND CEMENTATION:** *These are also known as* ***lithification processes*** (from the word lithosphere or crust)
   i. Compaction involves squeezing or compacting the sediments usually by burying them under water or other sediments.
   ii. **Cementation occurs when minerals grow in between the sediments to glue them together.** The most common mineral is **clay.**
   iii. **Since the sediments are only cemented together, sedimentary rocks are not as hard as igneous or metamorphic rocks**



3. Classifying Sedimentary Rocks
   a. Sedimentary rocks are classified according to the type of sediments they contain. There are three categories: Clastic, Crystalline, and Bioclastic
      i. ***Clastic sedimentary*** *rocks are made from fragments of other rocks and minerals that are compacted and cemented together. Fragments may be gravel or sand or clay size. Larger grained rocks will be found towards the highlands while smaller grained rocks will be found towards the shoreline and ocean*
      ii. ***Crystalline sedimentary*** *rocks are made from minerals that were previously dissolved then precipitated out of water solutions. The precipitation occurs when the water evaporates and leaves the cemented sediments behind. These rocks will be found towards the shoreline and ocean.*
      iii. ***Bioclastic sedimentary*** *rocks are made from sediments that include fossils or the remains of once living things. These are cemented together by clay or other*

minerals. These rocks will be found toward the highlands, shoreline, or ocean based on its composition.

4. ***Once formed rocks do not remain unchanged for long. These changes are referred to as*** ***THE ROCK CYCLE***

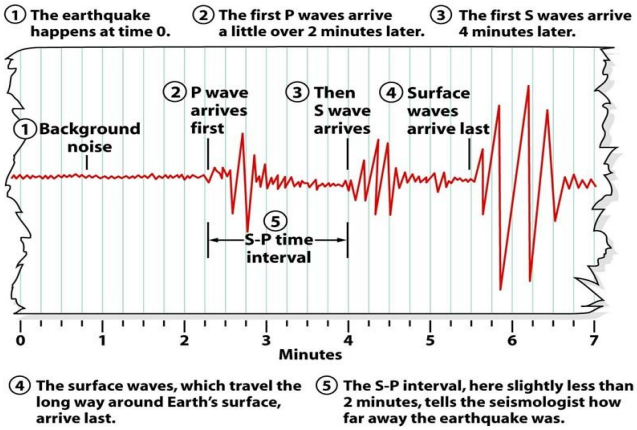


Elastic Rebound Theory -

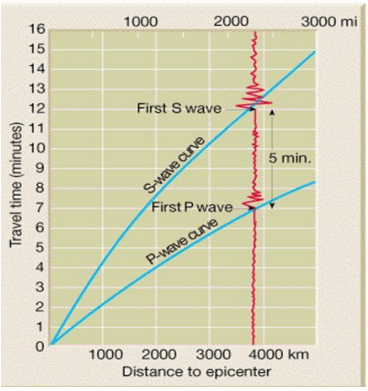
1. Theory that rocks build up POTENTIAL energy and deform (bend) as two plates interact with each other at a boundary. The slippage of the fault releases this energy and the rocks will unbend. The energy travels away from the fault as seismic waves.
2. The FOCUS is where the plate slips and the earthquake starts below the Earth's surface.
3. The EPICENTER is the point above the focus on the surface of the Earth.

Earthquake Waves -

1. Earthquakes generate 3 main types of waves: Primary (P), Secondary (S), and Surface waves (Love and Rayleigh)
2. The P-wave arrives first, followed by the S-wave, then the Surface wave
3. The epicenter of an earthquake can be located by measuring the time difference of P and S waves and use to find the radius distance. The radius distance can be drawn on a map to determine the earthquake epicenter distance. **A minimum of 3 seismogram stations are needed as they will intersect at one point (which will be the epicenter).**



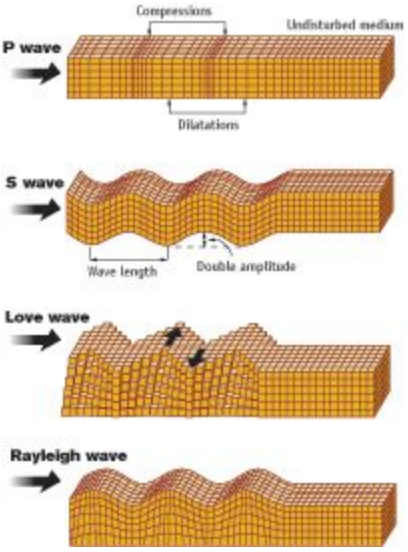
Travel-time graph



Fit the time difference between the first P-wave and first S-wave in-between the blue curves

Read off distance to epicenter

4. P-waves are LONGITUDINAL (COMPRESSION) waves. They push and pull on the medium. The rocks and the waves are parallel to each other.



5. S-waves are TRANSVERSE waves. They move the medium at right angles (perpendicular) to the direction the wave travels.

6. Surface waves are long slow waves. They are categorized as LOVE or RAYLEIGH waves. Love waves cause horizontal shifting (side-to-side) of the Earth during an earthquake. Rayleigh waves are rolling (up and down, forward and back) waves like waves in the ocean.

7. The speed of a seismic wave can be calculated using the equation **V = D ÷ T (Velocity = Distance ÷ Time)**

MEASURING EARTHQUAKES

A. MAGNITUDE SCALE

a. **Magnitude is determined by measuring the amount of ground movement caused by the earthquake**
b. The Richter scale is a magnitude scale
c. The higher the number the stronger the earthquake
d. The energy of an earthquake increases by a factor of 30 for every number higher on the scale from 1-10

B. MERCALLI SCALE

a. **Intensity scale that determines the amount of damage and other effects of the earthquake**
b. The higher the number the more damage the earthquake does
c. The Mercalli intensity scale uses Roman numerals from I to XII

Graphing -

Line graphs are used to determine the relationship between variables

1. Label the axes and include units
2. Place the smallest value, from the data, on the first line of the graph. Do this separately for both axes
3. Determine the scale for each variable (Range ÷ # of lines). DO NOT include the line with the smallest value. Never round the scale down (always round up)
4. Plot the data points
5. Draw a best fit line or curve
6. Title the graph (use independent vs dependent)
7. Determine the slope = $\frac{(y2-y1)}{(x2-x1)}$ using 2 points on the line
8. A positive slope = increase of both variables (the line slopes upwards)
9. A negative slope = increase of one variable follows a decrease in the other variable (the line slopes downwards)
10. No slope = a horizontal line with no trend or relationship