Topic 6.4-6.5: Notes
6. 4 Earthquakes

A. *What are Earthquakes and what causes them?*
1. Earthquakes are the shaking and vibrating of the Earth's crust. This occurs at points of weakness in the crust or at breaks in the crust that are called **faults**.

2. The Earth's crust is made of fragments called **plates** and they are slowly moving about the surface. Earthquakes happen most frequently where these plates meet, which is called **plate boundaries**. When two plates "rub" against one another, they do not move continuously, but instead stress builds up until it is too great and the energy is released violently and the plates move. The energy that is released is called **seismic energy** and it is responsible for the destruction caused by earthquakes.

B. *What are seismic waves?*
1. Seismic energy is released in the form of waves called seismic waves. **Seismic waves** travel outward in all directions from the exact location that the earthquake originated below the surface, which is called the **focus**.
Specific Types of Seismic Waves:
   a) **P-waves** (AKA primary, push-pull and compressional waves) are the **fastest** traveling seismic wave and can travel through **both solids and liquids**.
   b) **S-waves** (AKA secondary, side to side and shear waves) are slower than P-waves and can **only** travel through **solids.**
   c) **L-waves** (AKA long or surface waves) are the slowest seismic wave, but the most destructive because they travel along the surface.

C. *What is an epicenter and how is it located?*
1. An epicenter is the location on the Earth's surface directly above the focus of an earthquake.
2. Distance to the epicenter can be located by using an instrument called a **seismograph**. A seismograph records the **arrival times** of the seismic waves. Scientists know how fast these waves travel and by observing the difference in arrival times of the S-waves and the P-waves, we can calculate the **distance to the epicenter**. We use the **ESRT page 11**.

Seismic Station B: P-wave arrival time = 1:01.00 PM
                            S-wave arrival time = 1:06.20 PM
                            Arrival time difference = _____
                            Distance to epicenter = _____
                            Origin Time = _____
Seismic Station C: P-wave arrival time = 4:30.20 PM
                            S-wave arrival time = 4:33.40 PM
                            Arrival time difference = _____
                            Distance to epicenter = _____
                            Origin Time = _____

3. Although the distance to the epicenter can now be found, the exact location is still unknown. In order to find the **exact location** of the epicenter, you must have information from **three (3)** seismographs at separate locations.

This is a map and 1 cm = 1,000 km. Letters A, B, C are seismograph stations. Find the **exact location** of the epicenter if the distance to the epicenter from seismograph station A is 3,200 km.
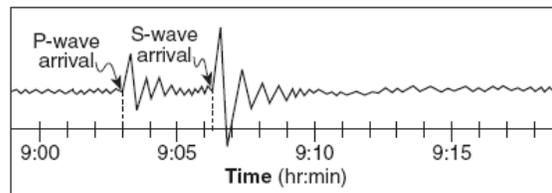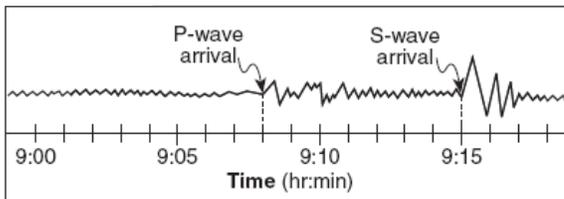
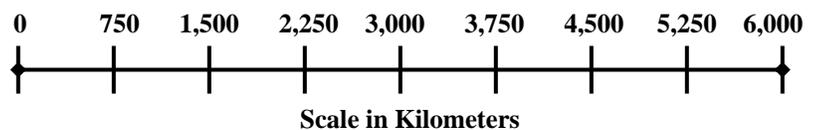• B   • A

• C

Wash. DC.   **Seismogram Tracings**   **Seattle**

P-wave arrival   S-wave arrival

9:00   9:05   9:10   9:15
Time (hr:min)

P-wave arrival   S-wave arrival

9:00   9:05   9:10   9:15
Time (hr:min)

Use the seismic data above to calculate the epicenter distances and to draw the circles using the scale provided. Finally, locate and mark the earthquake's epicenter.

Great Lakes

Seattle   Missouri

Mississippi   Ohio   New

WAS

Los Angeles

Houston

Gulf of   Miami

MEXICO   BAHAM

0   750   1,500   2,250   3,000   3,750   4,500   5,250   6,000

Scale in Kilometers

Topic 6.4-6.5: Notes

6. 5 Earth's interior

A. How do scientist know anything about the Earth's interior if we have ONLY drilled 7.5 miles (12 KM) below the surface?

1. Our understanding of the properties of the Earth's interior comes from studying earthquake waves. Through hi-tech instruments and math, we have analyzed seismic waves and **inferred** the **thickness, composition, temperature** and **pressure** of the different layers within the Earth.
2. Velocity of all seismic waves increases when they pass through more dense material. The density of rock increases as the depth into the Earth increases.
3. When an earthquake occurs, only P-waves can be detected by seismograph stations on the other side of the Earth.

In your own words, please explain why P-waves ONLY are detected on the other side of the Earth.

B. What are the different layers of the Earth and their properties? (ESRT pg. 10)

1. <u>The Crust</u>- is a solid layer, which consists of continental and oceanic crust. This layer is relatively thin compared to the other layers.
      a) <u>Continental crust</u> is made of ***Granite***, which is a low-density igneous rock and has an average thickness of 20-40 km.
      b) <u>Oceanic crust</u> is made of ***Basalt***, which is a high-density igneous rock and has an average thickness of 10 km.

2. <u>The Lithosphere</u> is a term that refers to both the crust and the uppermost part of the mantle. It is rigid and about 100 km thick.

3. <u>The Mantle</u>- is divided into two parts:
      a) The <u>Asthenosphere</u> is directly below the lithosphere. It is a semi-plastic **fluid-like** layer that the **tectonic plates are resting upon** and has an approximate thickness of 400 km.
    $\Rightarrow$ As you know, seismic waves change speed as they pass through different density substances. This fact allowed the "Mohorovicic discontinuity" (the **Moho interface**) to be discovered between the lithosphere and the asthenosphere.

      b) <u>Lower Mantle</u> is stiffer and denser than the Asthenosphere and has an approximate thickness of 2,400 km.

4. The Outer core – is a *liquid* layer and consists mainly of Iron and has a density of 9-11 g/cm$^{3.}$ **Remember**: S-waves cannot travel through this layer so it inferred to be liquid.

5. The Inner Core is a solid layer that is believed to consist of Iron and Nickel. The core has a density of 10.5 – 15.5 g/cm$^{3.}$

In the boxes, label each layer on the diagram to the right.

Earth's Interior
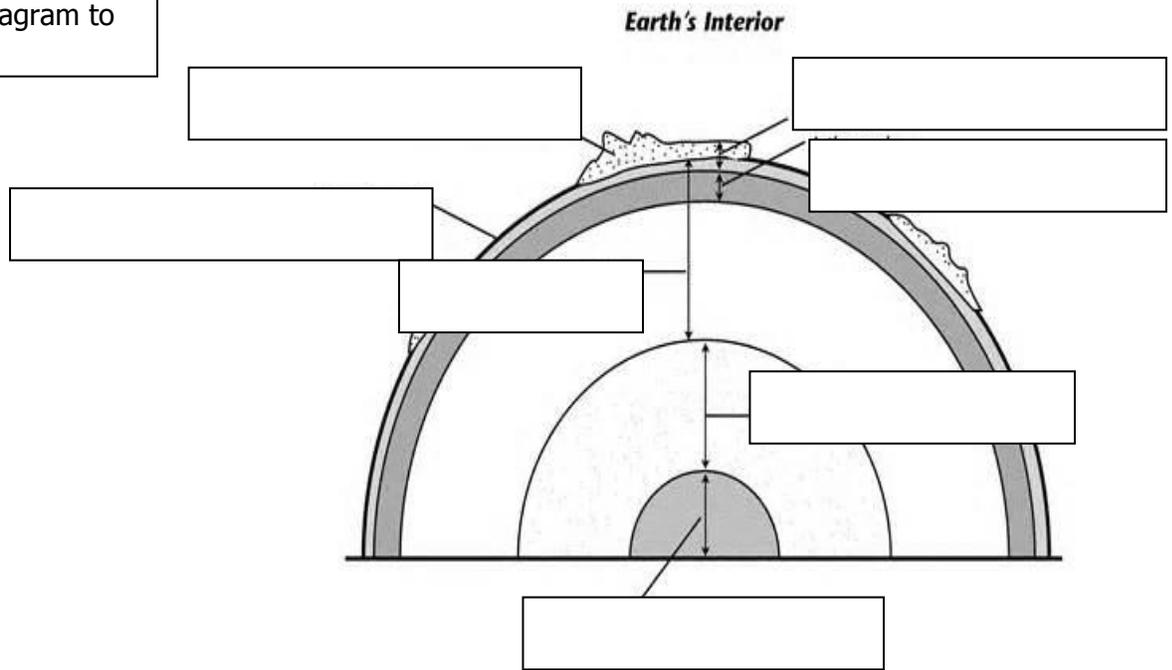
In the boxes, write what seismic waves would be received in that area by seismographs.

Earthquake Epicenter

X