Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Period\_\_\_\_

**Note Outline: Earth Science Chap 19 Earthquakes**

1. Define stress vs. strain as they apply to rocks.
2. Define faults.
3. Contrast types of seismic waves-3 types according to their type of movement, speed, location
4. Focus vs. epicenter
5. Explain how seismic waves give clues about Earth’s interior
6. Compare & contrast magnitude & intensity, and the scales to measure each
   1. Richter vs. Mercalli scale
7. Describe Earth’s seismic belts
8. Locating an epicenter; Explain why data from at least 3 seismic stations is needed.
9. Mining of resources: Investigate the cost-benefit ratio, risks and impact on the environment.

**Introductory Activity: Cookie Mining**

**Natural resource** = Material found in nature that is useful or necessary to humans

1. **Cost-benefit ratio** is a calculation used to determine if the resource can be mined at a profit. Costs of your Cookie Mining activity included:
   1. Purchase of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_on which to mine, (cookie)
   2. Purchase of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (toothpick & paperclips)
   3. Cost of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (time it took to get chocolate chip out of cookie)
   4. Cost of\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – putting the land back into the condition it was found in.
2. Was yours mined at a profit, yes or no? Explain why or why not in the space below.

1. Was your reclamation successful? Explain including the following:

\*\*Were all your “scraps” able to fit in the original space?

\*\*Did the “property” look the same as it did originally?

1. Describe difficulties you think might occur with reclamation in real mining.

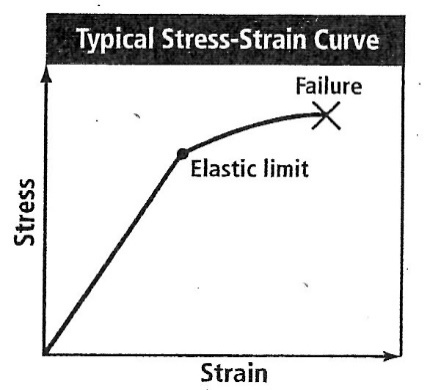
**Section 19.1 Forces within Earth**

**Stress:** A \_\_\_\_\_\_\_\_\_\_\_\_\_ that acts on rock to change its shape or volume

**Strain:** Deformation (\_\_\_\_\_\_\_\_\_\_\_\_\_\_) of material in response to stress

**Types of Strain:**

1. **Elastic strain:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_deformation (bending, compression

 or stretching). Goes back to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ shape when

stress is gone

* 1. **Elastic limit:** Amount of stress a rock can withstand and still return to original shape

1. **Ductile deformation:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ deformation.

\_\_\_\_\_\_\_\_\_\_\_\_\_ return to original shape after stress is gone.

1. **Failure:**  Material (rocks) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Faults:**\_\_\_\_\_\_\_\_\_\_\_\_\_ in Earth’s crust along which \_\_\_\_\_\_\_\_\_\_ occurs when stress causes \_\_\_\_\_\_\_\_\_

* 3 subtypes: Depending on the plate boundary type

**Transform Boundaries**: 2 plates \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ past each other

* 1. Crust is NEITHER consumed or created, only deformed and fractured
  2. Causes earthquakes
  3. NO volcanoes
  4. No link to convection
  5. Example locations: San Andreas Fault in California

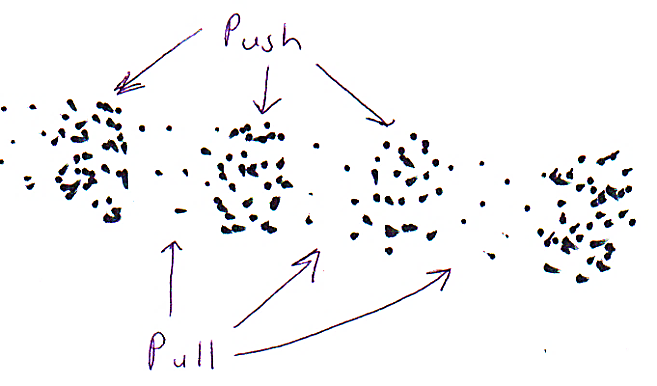
**Earthquake Waves:**

* Caused when \_\_\_\_\_\_\_\_\_\_\_ is reached and rocks fail or break. Due to pressure build-up when rocks

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

* 3 Wave Types Exist in EVERY Earthquake

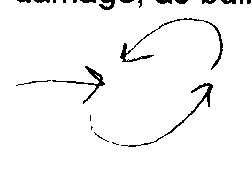
**3 subtypes of Waves**

1. **Primary Waves**: Rock particles move back & forth in the \_\_\_\_\_\_\_\_\_ direction that the wave travels
   1. AKA P-wave: \_\_\_\_\_\_\_\_\_\_\_\_\_\_ wave
   2. Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)
   3. Can travel through \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, but slowed & bent in liquid
   4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ wave. Arrives at seismograph station \_\_\_\_\_\_\_
   5. Diagram:

1. **Secondary Waves:** Rock particles move at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the direction the wave travels
   1. AKA S-wave: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ wave

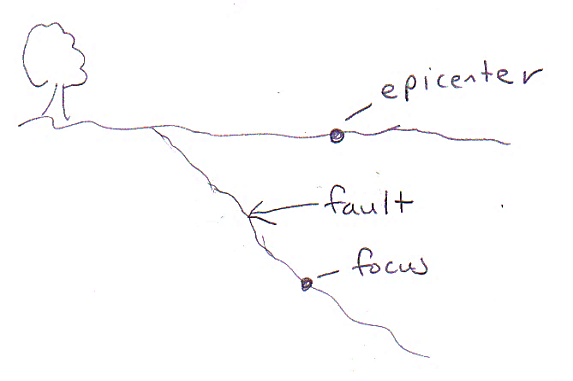
* 1. Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)
  2. Can ONLY travel through \_\_\_\_\_\_\_\_\_\_\_\_\_\_. Therefore some seismograph stations don’t receive S waves.
  3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ speed wave
  4. Diagram:

1. **Surface Waves:** Rock particles move in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ at once: backward, rolling motion & side to side swaying motion
   1. No nickname
   2. Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Start at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, NOT focus)
   3. Causes most of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

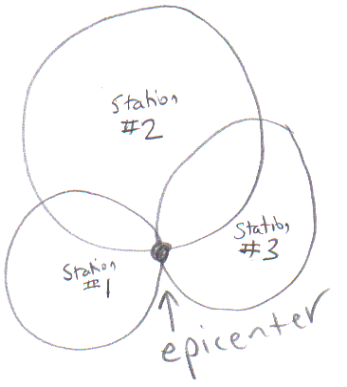
* 1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ wave
  2. Diagram:

**Focus:** Point where earthquake originates \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ & S & P seismic waves \_\_\_\_\_\_\_\_\_\_\_

**Epicenter:** Point on earth’s \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ directly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the focus.

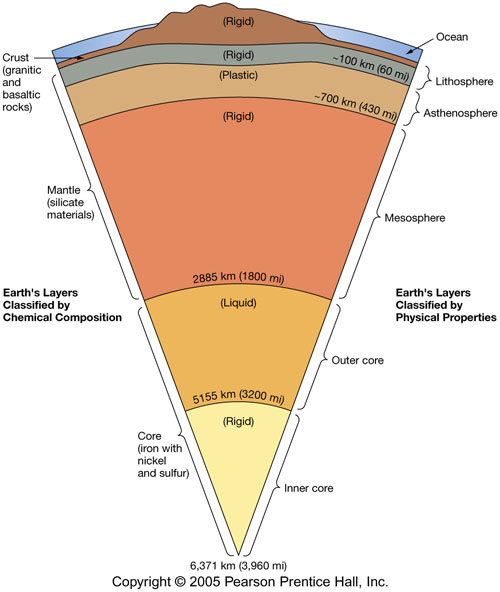


**Locating an Earthquake:**

1. **Epicentral distance** = The distance between the seismic station and the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Must have a minimum of \_\_\_\_seismic station readings to determine the epicenter location. Why?
   1. If there is only 1 station, the epicenter could be\_\_\_\_\_\_\_\_\_\_ on the circle (distance is the radius of circle)
   2. If there are 2 stations, the epicenter could be in \_\_\_\_\_\_\_\_\_ places
   3. If there are 3 stations, the epicenter could be in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ - where all three circles meet

1. Most earthquakes occur in **seismic belts** along \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Earth’s interior:**



Lower Mantle

1. **Inner core:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, dense. Made mainly of \_\_\_\_\_\_\_\_\_\_\_\_.
2. **Outer core:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, mainly iron.
3. Mantle: Largest layer of earth. 3 parts of mantle based on phase:

* Lower (Inner) Mantle: Very viscous & solid-like
* Asthenosphere: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Upper (Outer Part) of the Mantle: Made of solid rock

1. **Crust:** Outermost layer. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ crust is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ than oceanic crust.
2. **Lithosphere plates:** \_\_\_\_\_\_\_\_\_\_\_\_\_ combination of

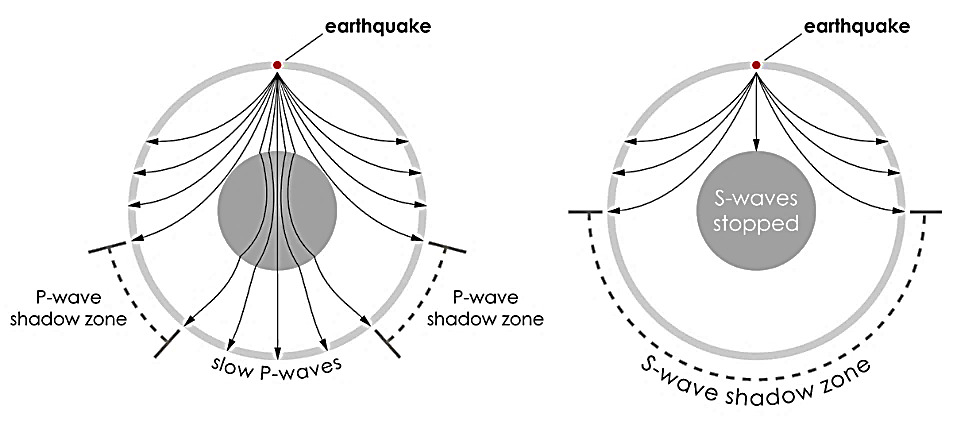
\_\_\_\_\_\_\_\_\_\_\_ & \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Clues to Earth’s Interior**

**When waves hit Earth’s core:**

1. **Shadow Zones:** Areas of Earth that do not detect seismic waves because
   1. P-waves are refracted (\_\_\_\_\_\_\_\_\_\_\_) & \_\_\_\_\_\_\_\_\_\_\_\_ by the liquid outer core

* 1. S-waves do \_\_\_\_\_\_\_ enter the liquid core. They \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and are lost.



1. Wave speeds can be used to map Earth’s internal structure and determine:
   1. Whether it is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. Determine the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_-iron vs. granite, etc.

**Section 19.3 Measuring & Locating Earthquakes**

1. **Seismologist:** Scientist who studies earthquakes
2. **Magnitude:** Amount of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_released during an earthquake. Based on:
   1. **Richter scale:** Measures (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) magnitude of an earthquake
      1. Based on size of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ seismic waves on a seismogram
      2. No upper limit
      3. Most earthquakes are \_\_\_\_\_\_\_\_\_ to be \_\_\_\_\_ by humans (< 3.0)
      4. Only \_\_\_\_\_\_ number on the Richter scale for each quake
3. **Intensity:** Amount of \_\_\_\_\_\_\_\_\_\_\_\_\_\_ & \_\_\_\_\_\_\_\_\_\_\_ damage
   1. **Modified Mercalli Scale:** Measures intensity in a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ location
      1. Roman numerals I to XII
      2. I (low) is not felt **vs**. XII is total destruction
      3. Damage is caused by \_\_\_\_\_\_\_\_\_\_\_\_\_waves
      4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_numbers for each quake, as different locations have different amounts of damage
      5. Dependent on: magnitude, depth of quake, type of rock or surface material, structure design & distance from epicenter.

**Section 19.4 Earthquakes & Society**

**Tsunami:** Large \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ wave created by vertical motion of ocean floor during a quake

1. At sea, the wave is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ high
2. As the wave enters shallow water & height increases to over 30m (100 feet)
3. Speeds of 500-800km/h
4. Spreads in all directions across the entire ocean

**Fracking:** **Questions for Reading of the “Fracking Background Essay”** on the last page of this packet.

1. What is **fracking**?
2. **Solid materials**:
   1. What are examples of solid materials added to the fracking fluid?
   2. What is the purpose of the solid materials?
3. **Chemical additives**: List 3 reasons chemicals are added to the fracking fluid.
4. **Diagrams: “Geology of Natural Gas Resources” and “Hydraulic Fracturing”**.

\*\*Examine the diagrams.

\*\*Compare & contrast a Conventional Drill vs. a Hydraulic Fracking drill. Include both similarities and differences.

1. Chemical additives make up only a small percentage, 2%, of the fracking fluid. Explain how a small percent can still be a danger.
2. Are mining companies required to tell what chemicals are in their fracking fluids? Why or why not?
3. Based on what you have read in the article, do you think that gas drilling companies should be compelled to tell the public which chemicals they are using in their fracking fluid? Why or why not?
4. How has fracking, and all forms of oil drilling, been linked to increasing numbers of small earthquakes in Oklahoma and other places in the U.S.?

**Bellwork #1**

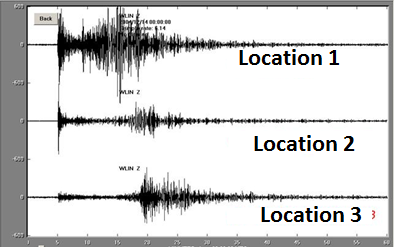
* 1. Compare and contrast **focus and epicenter**.
  2. Compare **stress and strain**.
  3. Compare **surface vs. interior rocks** in their response to stress;
     1. How does brittleness vs. ductility compare?
     2. How does their ability to withstand stress prior to failure compare?

**Bellwork #2**

1. Are the following parts of the **Richter or Mercalli** scale?
   1. 8
   2. VIII
   3. Based on seismogram wave height?
   4. More than 1 number is possible for a given earthquake
2. How is it possible to have:
   1. A low Mercalli number with a high Richter number?
   2. A high Mercalli number with a low Richter number?

**Bellwork #3**

1. Label the P and S-waves at all 3 locations below.
2. Use the difference in arrival times of P and S waves to determine which reading was taken farthest from the earthquake’s epicenter. Explain how you know.



**Fracking Background Essay** PBS Learning Media. <https://iptv.pbslearningmedia.org/resource/envh10.sci.phys.energy.fracking/fracking/>

**The NEED Project: Exploring Oil and Gas** [www.NEED.org](http://www.NEED.org)

Hydraulic fracturing, also known as fracking, is a process that injects fluid at high pressure deep underground to open and enlarge cracks in rock formations. This process stimulates the flow of natural gas, increasing the amount that can be extracted. Most fracking fluids are water based. A solid material, such as sand or ceramic beads, is added to the fracking fluid to keep the fractures open and permeable after the pressure is reduced. Other chemical additives are used, depending on the characteristics of the particular well. For example, some chemicals reduce friction to allow pumping at a higher rate than with water alone; others help dissolve minerals; and some prevent bacterial growth.

Many of the chemicals used in fracking fluids can also be found in foods, cosmetics, soaps, and household cleaners. However, that does not mean that they are safe; dosage is an important factor when evaluating hazardous materials. Although the total concentration of chemical additives in fracking fluid is generally less than 2 percent, millions of gallons of fluid are typically used to drill a well. That means that thousands of gallons of chemicals could be used that might potentially impact human health and the environment.

In 2005, the Energy Policy Act exempted hydraulic fractured wells from regulation under the Safe Drinking Water Act. Some states may require disclosure of ingredients to state environmental agencies or health officials, but fracking fluids are largely unregulated. Mining companies each have their own proprietary formula. Some chemicals used in the fluids are known, but the exact compositions are kept confidential because they are claimed to be trade secrets. (The formula of a particular fluid may provide an advantage over other companies.) However, concerns over possible contamination of water resources from fracking fluids has led to controversy over whether the industry should be allowed to keep the formulas confidential.

Currently it is difficult to assess the connection between health problems and the fracking process because so little is known about the composition of the fluids. Even if a company discloses the chemicals it uses, the exact concentrations of chemicals may not be known. The Environmental Protection Agency has asked a number of fracking service providers to provide detailed information about their fluids as part of a study on the effects of fracking on drinking water and public health; research is due to be finished in 2012. Until more is known about the effects of the hazardous chemicals contained in fracking fluids, some people might argue that the industry should follow the precautionary principle—that it is their responsibility to protect the public from harm—and use safer chemicals in their fluids. Some companies are already making more environmentally friendly fracking fluids available.

Fracking and all forms of drilling produce liquid waste. Large amounts of waste are injected and stored underground. The underground waste storage has been linked to increasing numbers of small quakes in Oklahoma, Texas and other places in the U.S. According to Science magazine, wastewater quakes can even be triggered by large, natural quakes on the opposite side of the earth.