Handout 5.1 Homework Assignment 5.1: Earthquake Characteristics

1. Discuss the primary difference between using intensity and magnitude to characterize earthquake energy. Which is better in terms of characterizing energy? Why?

2. What is the ratio of energy release from a magnitude 5 earthquake compared to a magnitude 6? A magnitude 5 compared to a magnitude 7?

3. Explain why larger magnitude earthquakes are expected to cause greater damage.

4. Describe the equipment used to detect earthquake motions and determine earthquake magnitude. Are earthquakes monitored in your area? If so, where is the nearest seismograph station located relative to your location?

5. How are bomb blasts monitored for treaty verification purposes (i.e., nuclear test ban treaties)?

6. List the type of magnitude scales used by seismologist. Explain why so many different scales have been used. What is the current standard and when was this developed?

7. Explain how earthquakes are located.

8. How long would it take for an earthquake in California to be detected in Washington, DC, approximately 3,000 miles (4,500 km) away? Assume the majority of the energy will travel through hard rock layers.

9. Bonus question: How do scientists know that the center of the earth is liquid?

Handout 5.1 Homework Assignment 5.1: Answers

1. Discuss the primary difference between using intensity and magnitude to characterize earthquake energy. Which is better in terms of characterizing energy? Why?

   Intensity relies upon subjective measurements based on the response of people and objects. Intensity also is a measure of the effect of the earthquake. Intensity increases due to factors such as soil conditions and building practices which vary from region to region. Magnitude is a more fundamental measure of the earthquake energy as it is determined by instruments, and moment magnitude actually is a fairly good measure of earthquake energy. Thus, magnitude is the better parameter to use.

2. What is the ratio of energy release from a magnitude 5 earthquake compared to a magnitude 6? A magnitude 5 compared to a magnitude 7?

   Roughly 32 times per unit increase in magnitude, so M 5 to 6 = about 32, and M 5 to 7 is roughly 1000.

3. Explain why larger magnitude earthquakes are expected to cause greater damage.

   The severity of ground shaking (measured in terms of peak ground acceleration) increases with magnitude **up to a point**, but the duration of the earthquake and the potential for damage continuously increases with magnitude. For instance, a magnitude 7 earthquake might have peak ground accelerations just as high as a magnitude 8 event; however, the magntidue 8 event would definitely affect a much larger area and the length of time the ground shaking levels stayed at their maximum would be much longer – both factors that produce a higher damage potential. **Thus, damage potential to buildings and lifelines increase steadily with increasing magnitude.** And this damage potential is due only partly to stronger ground shaking, as the **increased duration of strong ground shaking and larger affected regions** are important causes as well.

4. Describe the equipment used to detect earthquake motions and determine earthquake magnitude. Are earthquake monitored in your area? If so, where the nearest seismograph station located relative to your location?

   Seismometers are used to detect earthquake motions. A seismograph, or seismometer, is an instrument used to detect and record earthquakes. Generally, it consists of a mass attached to a fixed base. During an earthquake, the base moves as the ground shakes and the mass does not. The motion of the base with respect to the mass is commonly transformed into an electrical voltage. The electrical voltage is recorded on paper, magnetic tape, or another recording medium. This record is proportional to the motion of the seismometer mass relative to the earth, but it can be mathematically converted to a record of the absolute motion of the ground. **Seismograph** generally refers to the seismometer and its recording device as a single unit. New seismometers are digital broad-band instruments that typically measure ground motions in three components. The units are deployed in the field across a region and are link back to the recording station via telephone lines, radio signal, microwave signals, or the Internet.

Yes. Nearest location is Virginia tech Observatory on Virginia Tech campus.

5. How are bomb blasts monitored for treaty verification purposes (i.e., nuclear test ban treaties)?

   Using the very same seismometer equipment used to record earthquake. In fact, it was the development of widespread monitoring equipment in the 1960s for the purpose of nuclear test monitoring that allowed data to be collected to confirm the theory of plate tectonics.

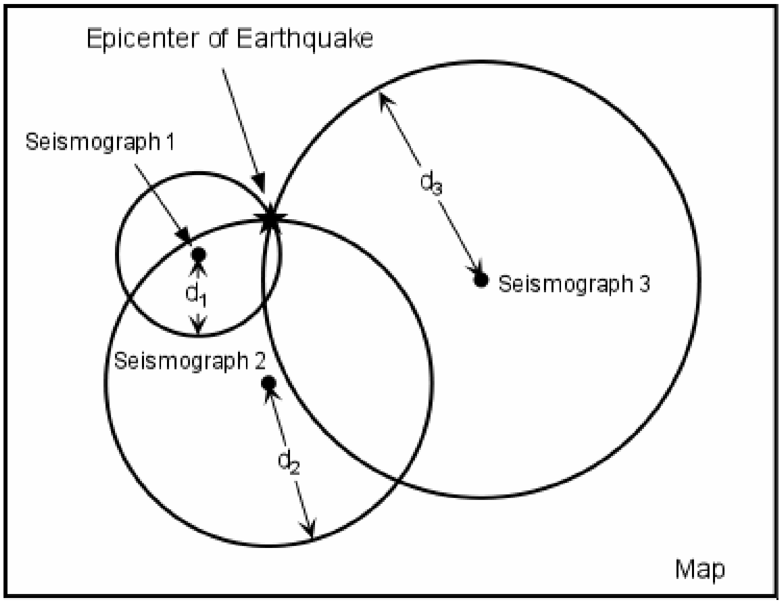
6. List the type of magnitude scales used by seismologist. Explain why so many different scales have been used. What is the current standard and when was this developed?

   Surface wave magnitude, body wave magnitude, local magnitude, moment magnitude are common scales. These scales were developed at various times since the beginning of the formal study of seismology when Richter first proposed his magnitude scale (what is now local magnitude). It was found that his scheme did not properly characterize earthquake energy for certain earthquakes. For instance, it was learned that very deep earthquakes that have little surface wave motion can be better characterized by measuring body waves and thus the body wave scale was developed for mainly for deep earthquakes, etc.

   Current standard is moment magnitude and this was developed in the 1980s.

7. Explain how earthquakes are located.

   Earthquakes are located by precisely recording the time that an earthquake wave is recorded at a variety of locations. By knowing the speed at which the waves travel through the earth’s crust, it is possible to back-calculate the distance to the source. When at least four stations have recorded the motion, the precise location and depth can be found by triangulation.

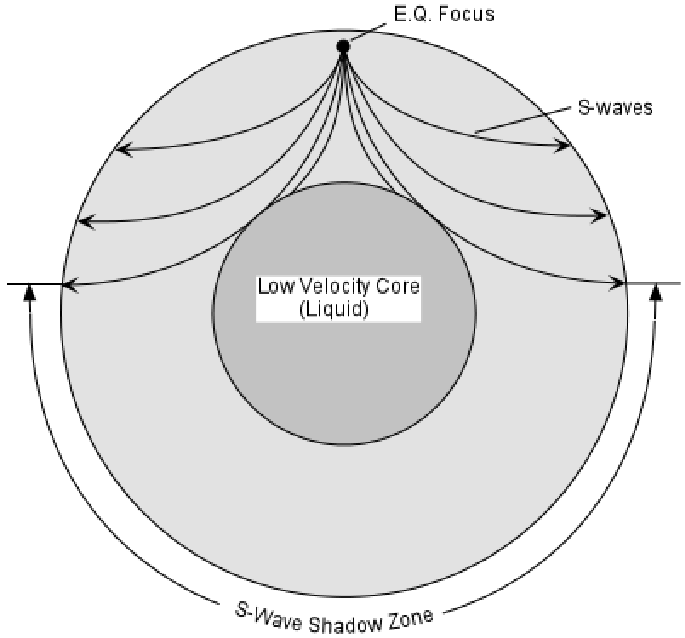


8. How long would it take for an earthquake in California to be detected in Washington, DC, approximately 3,000 miles (4,500 km) away? Assume the majority of the energy will travel through hard rock layers.

   The p-waves will arrive first, as they travel much faster than the secondary waves. Typical hard rock p-wave velocity is about 18,000 ft./sec, or roughly 5.5 km/sec, or 3.4 miles/ sec. So, 3000 miles ÷ 3.4 miles/sec. is roughly 880 seconds or about 15 minutes to detect p-waves.

9. Bonus question: How do scientists know that the center of the earth is liquid?

   This discovery was followed by the discovery of an S-wave “shadow zone.” The S-wave shadow zone occurs because no S-waves reach the area on the opposite side of the Earth from the focus. Since no direct S-waves arrive in this zone, it implies that no S-waves pass through the core. This further implies the velocity of S-waves in the core is zero. In liquids, S-wave velocity is equal to zero. From this it is inferred that the core, or at least part of the core is in the liquid state, since no S-waves are transmitted through liquids. Thus, the S-wave “shadow zone” as shown below is best explained by a liquid outer core.


E.Q. Focus
S-waves
Low Velocity Core
(Liquid)
S-Wave Shadow Zone