

Natural Disasters

Lecture 13

Ch 3 – Earthquake Geology and Seismology

Text Source Today:

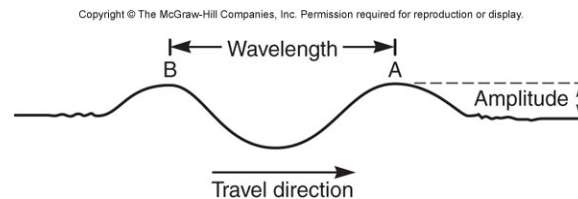
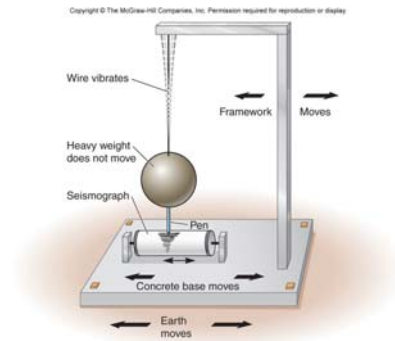
Chapter 3 (p. 59-65)

3.2: Ch. 3 – Earthquake Geology and Seismology

♦ **Seismology: the study of earthquakes.** Each year, the Earth is shaken by **millions of EQs**, most of which are small.

(Fig. 3.16)

♦ **Seismometers** detect Earth motions and records them on **seismographs** (in 3-D) as either north-south horizontal movements, east-west horizontal movements, or vertical movements. The **official time** is either tick-marked on the seismographic chart or imbedded within the digitized data.



● Waves Review:

- **wavelength** is the **distance** between successive waves, measured from either crest to crest (or trough to trough)
- **amplitude** is the **displacement** of the wave (equal to one-half the **wave height**, which is measured from trough up to crest)
- **period** is the **time** between waves (crests or troughs)
- **frequency** (measured in **hertz, Hz**) is the **number of waves** passing a given point each second (where 1 Hz equals one cycle per second, or one full wave passage per second)
- **period and frequency** are inversely related:

$$\text{period} = \frac{1}{\text{frequency}}$$

♦ **Seismic Waves:** when an earthquake occurs, it releases **energy in seismic waves** that pass through the whole body of the planet (**body waves**) and others that only move near the surface (**surface waves**).

♦ **Body Waves:** are fast moving and referred to as either **primary or secondary waves**; are most abundant at **high frequencies** of 0.5 to 20 Hz (0.5 to 20 cycles per second) and are thus, called **short-period waves**. (These are the most energetic for short distances close to the hypocenter/epicenter.)

♦ **Primary (P) Waves:** are **the fastest** and the **first** to reach a recording station and move (in the **direction of motion**) in a **push-pull** fashion of alternating pulses of compression (push) and extension (pull), similar to the motion of a **“Slinky” toy**.

♦ **P-waves** radiate outward from their source in an ever-expanding sphere and can travel **through any material (solid, liquid or gas)**, with their speed dependent on the density and compressibility of the materials through which they pass (**the greater the density, the greater the speed**).

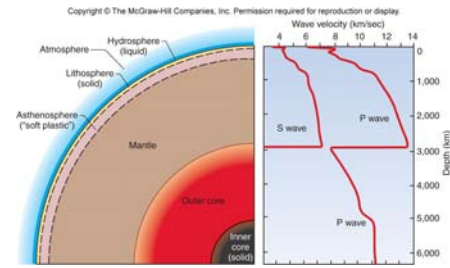
♦ **Secondary (S) Waves:** are the **second waves** to reach a recording station and move in a **transverse** motion by shearing or shaking particles in the path at **right-angles** to the direction of motion, similar to shaking a **jump rope** up and down.

♦ **S-waves** also radiate outward from their source, but **only travel through solids**; upon reaching liquid or gas, the **S-wave** energy is either **reflected back into rock** or is **converted to another form**, with their speed dependent on the **density and resistance** to shearing of the materials.

● Seismic Waves and Earth's Interior:

● As **P and S waves** travel through the Earth, they speed up, slow down, change direction, and the **S-waves** even disappear! Analysis of their travel paths gave us the indirect model view of

Earth's interior and revealed that there is a **solid inner core surrounded by a liquid outer core.** (Fig. 3.19)



◆ **Surface Waves:** travel near the **Earth's surface** and are either **Love or Rayleigh waves**, and are referred to as **L-waves** (long waves) because they are **low-frequency, long-period waves**; they carry significant amounts of energy for much greater distances away from the epicenter.

◆ **Love Waves:** their motion is similar to **S-waves**, except that it is from **side-to-side** in a horizontal plane, roughly parallel to Earth's surface (keeping the shearing motion at **right-angles** to the direction of motion); imagine the **jump rope on the ground**.

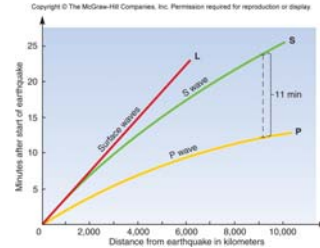
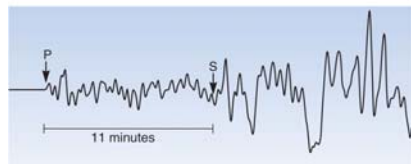
◆ **Love waves** travel faster than **Rayleigh** waves, but like **S-waves, only travel through solids**.

◆ **Rayleigh Waves:** their motion is in a **backward**-rotating, elliptical motion (similar to **forward**-rotating, wind-blown water particles in **ocean** waves) and causes both **vertical and horizontal** movement.

◆ **Rayleigh waves** have **long periods** and once started, they go **a long way**, passing through ground and water; can give the "feeling" as though the **ground became a rolling sea!**

● **Locating the Source of an Earthquake:** using the **lengths of time** the various **seismic** waves take to reach a seismograph, the locations of the **hypocenter** and **epicenter** can be determined.

(Figs. 3.21-22)



♦ **P-waves** travel about **1.7 times faster** than **S-waves**; the farther away from the earthquake epicenter, the greater the difference in **arrival times between the two waves**.

♦ **Epicenters** can be located by “**triangulating**” at least **three (3)** recording stations.
(Fig. 3.23)

● **Magnitude of Earthquakes:** an estimate of the relative **size or energy release** of an earthquake.

♦ **Richter Scale, M_L , (Charles Richter, 1935):** the best-known scheme of assessing the **magnitude** of an earthquake, but was devised for **California** EQs, with **shallow** hypocenters, that are located **near (fewer than 300 miles)** from the seismometers.

● Richter based his scale on the idea that the **bigger the EQ**, the greater the **shaking** and thus, the greater the **amplitude (swing) of the needle lines** on the seismogram.

♦ The Richter scale is a **logarithmic (base 10) scale**, where for every **10-fold** increase in the **shaking amplitude** of the recorded seismic wave, the Richter magnitude increases by **one number** (e.g., **4 to 5**). The scale has **no** upper or lower limit.

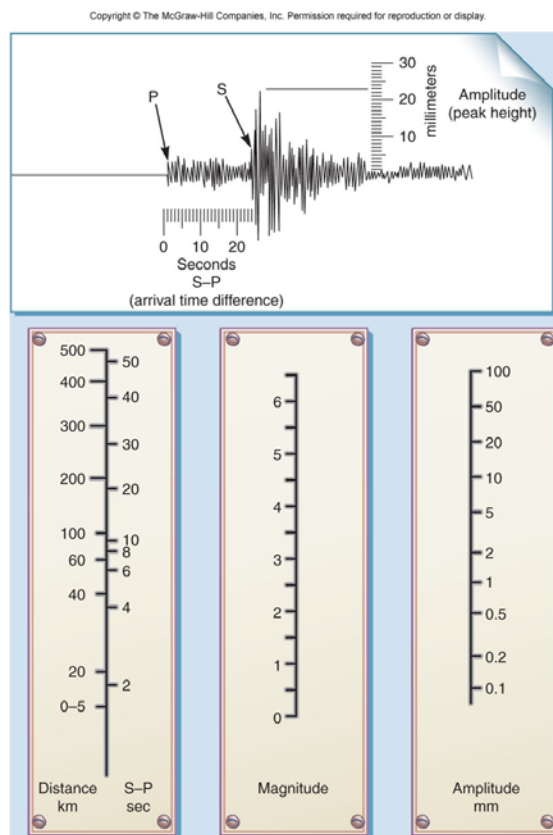
♦ The **energy** released by earthquakes **increases even more rapidly** than the 10-fold increase in amplitude of the seismic wave trace, as the **1.5 power** of the shaking amplitude: Mag. Diff. of 1 $\equiv (10^{1.0})^{1.5}$

● The **larger EQ energy** means that more people in a **larger area** and for a **longer time** will experience the **intense shaking**.

Richter Scale Energy Release

Diff.	Inc. Energy
1	32
2	1000
3	31623
4	1 million
5	31.6 million
6	1 billion

♦♦ **Computing a Richter Magnitude:** is quickly done by using a “nomograph” (see below) and measuring: (1) **the S-P arrival time difference in seconds**; and (2) **the amplitude of the S-wave in millimeters**.



(Fig. 3.24)

Homework (see class web page for due date of assignment):
<http://nemo.sciencecourseware.org/eec/Earthquake/>