"Seizing" Up the Quake: The Measurement

By Trista L. Pollard

[1] The earth shakes and shifts in many places. So, how do seismologists determine where seismic activity takes place? How do they know what magnitude the earthquake registers on the Richter scale? Let us examine the methods seismologists use for "seizing" up an earthquake.

[2] When an earthquake begins, the compressional or P waves are the first to arrive. This is usually in the form of a sharp thud. Next, the shear waves or S waves join in the seismic party (moving at 5 kilometers per second). The last waves to arrive are the surface waves. There are two types of surface waves called **Love waves** and **Rayleigh waves**.

[3] Love waves, also called L waves, were named after British mathematician A.E.H. Love. He designed a mathematical model for L waves in 1911. L waves move from side to side, and they are the fastest surface wave. They also cause destructive vibrations in buildings and break water and gas lines. The "ground rolling feeling" of an earthquake is produced by L waves. On seismographs, L waves also produce the largest vibrations.

[4] In 1885, scientist John William Strutt (Lord Rayleigh) mathematically predicted Rayleigh waves. Rayleigh waves roll along the ground the same way a wave rolls across an ocean. The ground moves up and down and side to side simultaneously in the same direction that the wave is rolling. These waves produce most of the shaking that people feel in an earthquake. Rayleigh waves may also be much larger than the other types of seismic waves. Seismologists use the seismograms produced by seismographs to study the arrival of the three different types of waves.

[5] Seismographs have a heavy weight suspended from a spring. The spring has a pen-like instrument attached. There is a receiving drum that contains recording paper. As the ground shakes, the drum revolves and moves up and down. The pen, which is motionless, draws a wave pattern onto the paper. Seismographs may also use a light beam to record seismic activity on photographic film.

[6] Since P waves are the first to arrive and travel faster than S waves, seismologists can determine the distance a specific seismograph is from an earthquake's epicenter. The **P-S interval** calculates this distance. This interval is the difference in the arrival times between the first P waves and the first S waves. When this difference is multiplied by 8 kilometers per second (the average speed of P waves), scientists can figure out the approximate distance of the seismograph station from the epicenter of the earthquake. The smaller the interval between the two arrival times, the closer seismograph is to the earthquake's epicenter. In addition to seismograph stations, seismologists use computers to help determine locations of earthquakes.

[7] Let's say there was an earthquake in Dallas, Texas. Seismograph Station A recorded an S wave that arrived 4.5 minutes after the P wave (the P-S interval). To find out Station A's distance from the epicenter, we would need to multiply 4.5 minutes by 60 to convert to 270 seconds. Then we would multiply 270 seconds by 8. We have found out that Station A is 2,160 kilometers from the earthquake's epicenter in Dallas. Ok, we have the distance of the seismograph from the earthquake epicenter. How do scientists determine the earthquake's magnitude?

[8] Seismologists have used the Richter scale as a measure of earthquake magnitude. When looking at a seismogram, scientists measure an earthquake's magnitude by taking the logarithm of the amplitude of waves that were recorded on the seismogram. **Micro earthquakes** measure less than 3.0 on the scale; **moderate earthquakes** measure 5 to 5.9; **major earthquakes** measure 7.0 to 7.9; and **great earthquakes** measure 8.0 or greater. Earthquakes that measure 4.5 or greater produce seismic activity that is strong enough to be felt by sensitive seismographs around the world.

[9] Throughout the years, seismologists have developed different ways of measuring an earthquake's magnitude. This was necessary to record more accurate readings at the numerous stations that were set up around the world. The Richter scale measures the local magnitude or **ML** based on recordings by local seismograph stations. Seismologists now measure **mb** (body wave magnitude), **Ms** (surface wave magnitude), and **Mw** (moment magnitude). Although each measurement (ML, mb, and Ms) refers to a specific type of wave, they are still equivalent to the Richter scale. Mw, which does not focus on ground movement at the seismograph station, gives the most reliable measurement of an earthquake's size. This measurement is based on the size of the fault where an earthquake occurs, and the amount the Earth slips along that fault. As scientists learn more about the Earth's "cough," "shakes," and "hiccups," they will develop even more accurate methods for "seizing" up earthquakes.

Name _____ Science Pd _____

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1. L waves cause _____.
   - (A) The least amount of damage to buildings
   - (B) B and C
   - (C) Destructive vibrations to buildings
   - (D) Water and gas lines to break

2. Seismologists use the P-S interval to determine the location of a specific seismograph in relation to an earthquake.
   - (A) False
   - (B) True

3. P waves usually feel like a _____.
   - (A) None of the below
   - (B) Sharp thud
   - (C) Low rumbling
   - (D) Ground roll

4. What is moment magnitude?

   _____

   _____

5. Surface wave magnitude or Ms measures the movement of seismic waves underneath the earth's surface.
   - (A) False
   - (B) True

6. Rayleigh waves cause the ground to move _____ in the direction of the wave.
   - (A) Up and down and side to side
   - (B) Front to back and up and down
   - (C) Side to side
   - (D) Back and forth and up and down

7. Station B also recorded the Dallas, Texas, earthquake. It recorded that the S wave arrived 3.2 minutes after the P wave. How far is this station from the earthquake's epicenter?

   _____

   _____

8. Which station is closer to the Dallas earthquake's epicenter? What is the distance in miles from each seismograph station? (Hint: multiply the number of kilometers by .6214)

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