3-Component Seismogram Records Seismic-wave Motion

How do we capture the motion of an earthquake?

Link to Vocabulary (Page 2)

Introduction

Most modern seismometers include three separate elements that allow the determination of the simultaneous movement in three different directions: up-down, north-south, and east-west. Following an earthquake, the ground responds to P, S, and surface waves by moving in all directions, and each direction of movement gives information about an earthquake. The different particle motion style is because each seismic wave has its characteristic movement: P waves are compressive and travel upward through the body of the earth, so have a strong vertical component. S waves, also body waves, move with a shearing motion side to side perpendicular to the motion of travel, so they have greater offset in the horizontal axes. Surface waves are the big movers and shakers. Love waves have a strong side to side motion parallel to the surface of the earth. Rayleigh waves are more complicated with a forward-up-back-down-forward rolling movement. See **Types of Seismic Waves.**

For background on seismometers, see the animations: (**Vertical** and **Horizontal**)

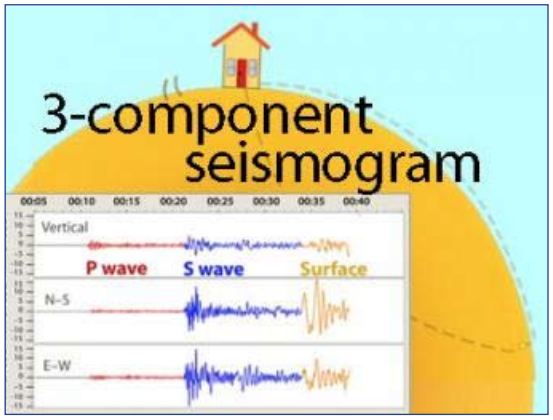


Figure 1 : *Screen grab of the animation. To view the animation, please visit:*
http://www.iris.edu/hq/inclass/animation/115

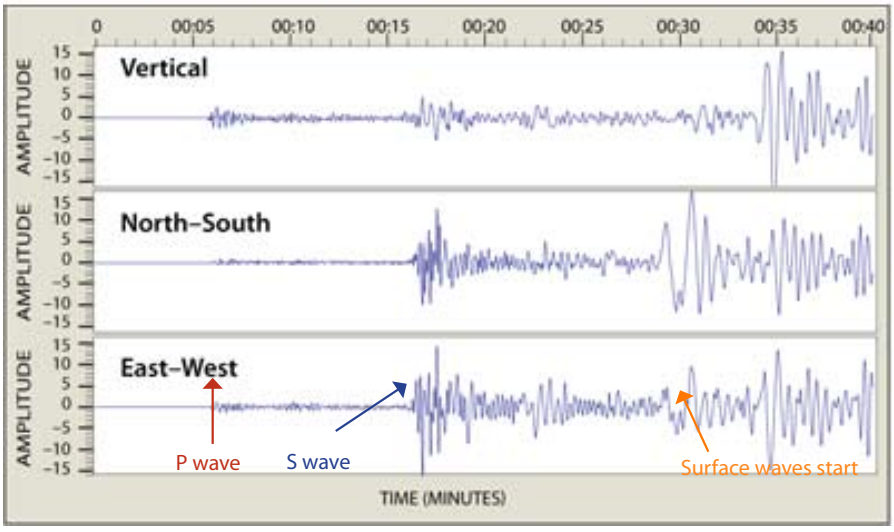


Figure 2: *The different behavior of P, S, and surface waves explain how the 3 seismometers in the seismograph station have different seismograms. 1) The vertical component shows the compressive P wave bumping up from beneath; it has very little horizontal movement. 2) The S wave is moving side to side in the direction of travel, so it has less effect bumping up from beneath the station than it does in its side to side motion. 3) Surface waves have a huge effect on all components.*

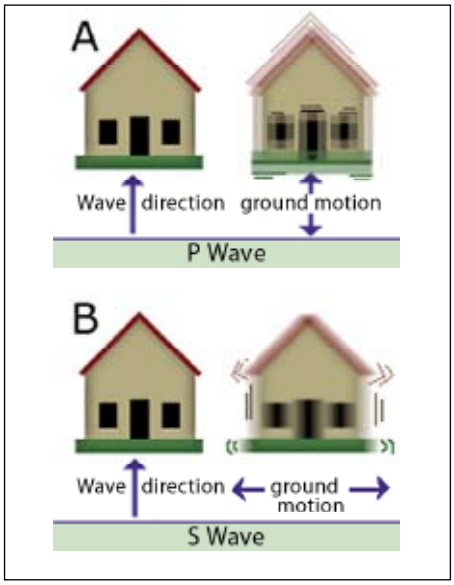
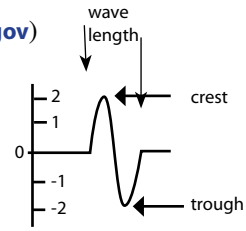


Figure 3: House Shake Motion
A: P waves, or compressional waves like sound waves, are seismic body waves that shake the ground back and forth in the direction that the wave is traveling.
B: S, or secondary waves or shear waves, that shake the ground back and forth perpendicular to the direction the wave is traveling.
C: [Not shown in images] Surface waves roll the ground in a back-and-forth, up-and-down motion.

Vocabulary

To accompany Background files for **IRIS' Animation page**. (Definitions from **usgs.gov; nasa.gov;** and **fema.gov**)



Amplitude—the maximum disturbance or distance from the constant point. On a seismogram the horizontal time line is flat until there is a ground disturbance which is recorded as wave, or *seismogram*. The amplitude of a seismic wave is the amount the ground moves up or down. Amplitude is one-half the distance between the crest and trough of one wave length. In drawing at right, maximum displacement is 2 + 2 = 4, so Amplitude = 0.5 * 4 = 2.

Body Waves—waves that move within the Earth's interior or within a body of rock. P and S waves are body waves.

Compression—fractional decrease of volume due to pressure.

Earthquake—shaking or trembling of the earth that accompanies rock movements extending anywhere from the crust to 680 km below the Earth's surface. It is the release of stored elastic energy caused by sudden fracture and movement of rocks inside the Earth. Part of the energy released produces seismic waves, like P, S, and surface waves, that travel outward in all directions from the point of initial rupture. These waves shake the ground as they pass by. An earthquake is felt if the shaking is strong enough to cause ground accelerations exceeding approximately 1.0 centimeter/second squared.

Love Waves—*surface waves* that move parallel to the Earth's surface and perpendicular to the direction of wave propagation..

P Wave—the primary body wave; the first seismic wave detected by seismographs; able to move through both liquid and solid rock..Also called compressional or longitudinal waves, they compress and expand (oscillate) the ground back and forth in the direction of travel, like sound waves that move back and forth as the waves travel from source to receiver. P wave is the fastest wave.

Rayleigh Waves—*surface waves* that move in an elliptical motion, producing both a vertical and horizontal component of motion in the direction of wave propagation.

Seismic Wave— an elastic wave generated by an impulse such as an earthquake or an explosion. Seismic waves may travel either through the earth's interior (P and S waves; the fastest waves) or along or near the earth's surface (Rayleigh and Love waves). Seismic waves travel at speeds of several kilometers per second.

Seismogram—A real-time record of earthquake ground motion recorded by a *seismograph*. Seismograms are the records (paper copy or computer image) used to calculate the location and magnitude of an earthquake..

Seismograph—an instrument that records vibrations of the Earth, especially earthquakes. Seismograph generally refers to the *seismometer* and a recording device as a single unit.. See **IRIS' Seismographs.**

Seismometer—a sensitive instrument that can detect waves emitted by even the smallest earthquakes. (See *seismograph*.)

Surface Wave—waves that move close to or on the outside surface of the Earth rather than through the deep interior like the faster P or S waves. Two principal types of surface waves, Love and Rayleigh waves, are generated during an earthquakes. Rayleigh waves cause both vertical and horizontal ground motion, and Love waves cause horizontal motion only. They both produce ground shaking at the Earth's surface but very little motion deep in the Earth. Because the amplitude of surface waves diminishes less rapidly with distance than the amplitude of P or S waves, surface waves are often the most important component of ground shaking far from the earthquake source.

S Waves—secondary body waves that oscillate the ground perpendicular to the direction of wave travel. They travel about 1.7 times slower than P waves. Because liquids will not sustain shear stresses, S waves will not travel through liquids like water, molten rock, or the Earth's outer core. S waves produce vertical and horizontal motion in the ground surface.