

Travel-time curves—distance from earthquake to seismic station

Background to accompany the [IRIS' Animation of the Month: Travel-Time Curves](#)

For background on *how to use this graph*, go to:

[IRIS' Animation of the Month: 3-Component Seismogram](#) and scroll down to:

read “**S minus P—arrival times determine distance to earthquake**” and

watch “**Reading Travel-Time Curves**” Video lecture.

Figure 1 (right): This is an example of a simplified travel-time curve showing the expected first arrival of P, S, and surface waves at a range of distances from the epicenter. It is important to notice that the difference between the S and the P times increases smoothly with distance. Therefore, a seismogram with a given S minus P arrival times will only match the travel time data at one specific distance.

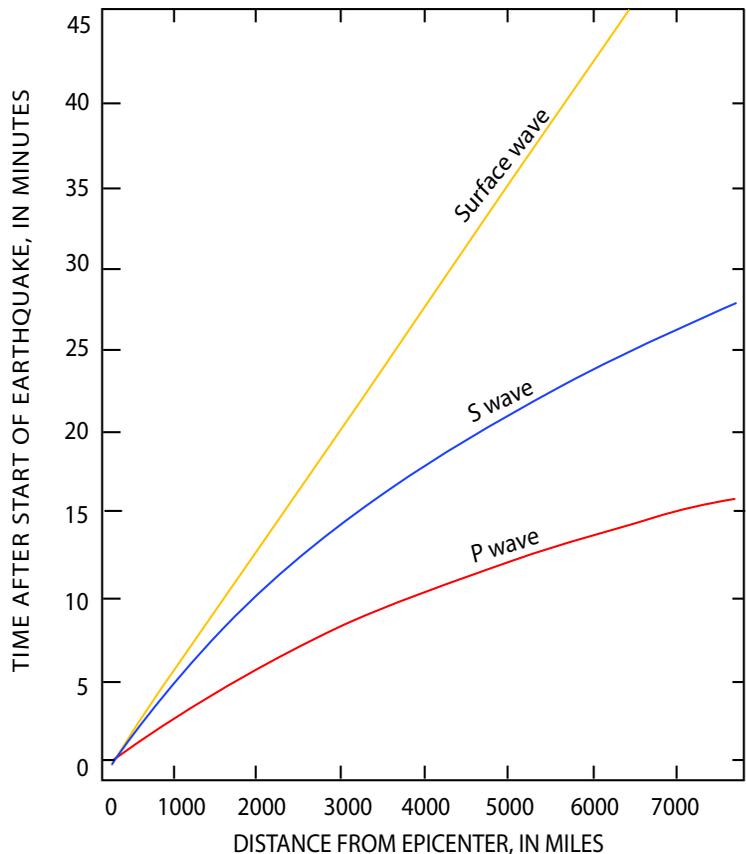
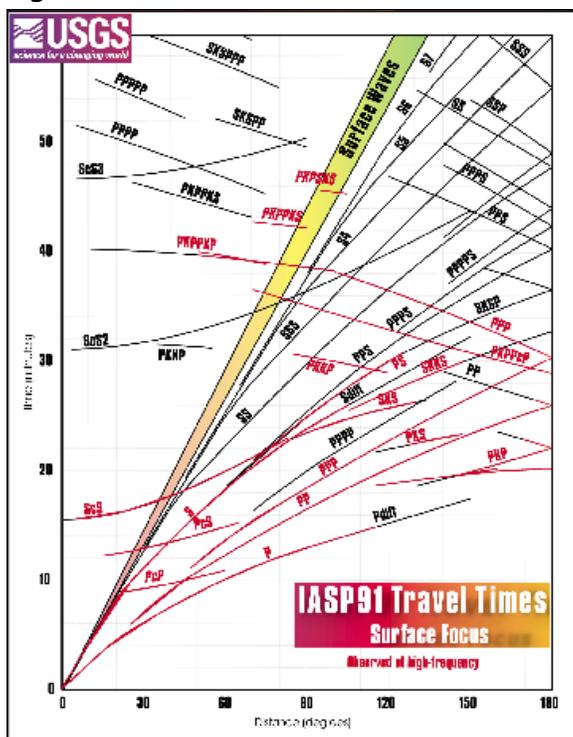


Figure 2 (below): This is an actual travel-time curve (IASP91) for body-wave phases for an earthquake at the surface. Like all travel time curves, this assumes a standard earth model (IASP91) to calculate the travel times. [Larger copy on [page 2](#) of this document.]

Figure 3 (bottom left): Cross section of the whole Earth, showing the complexity of paths of earthquake waves. (USGS image)

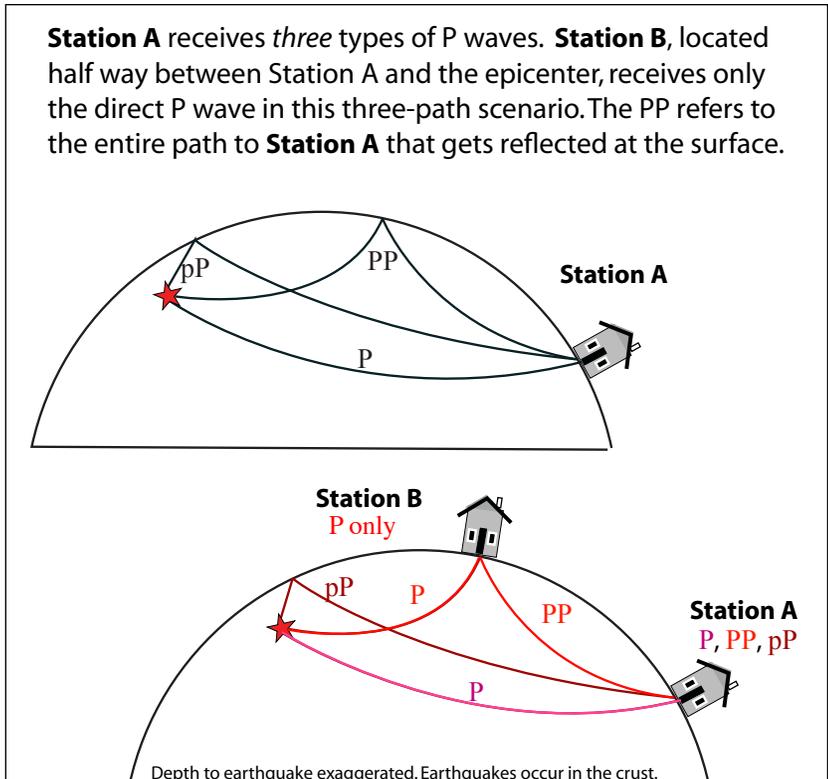
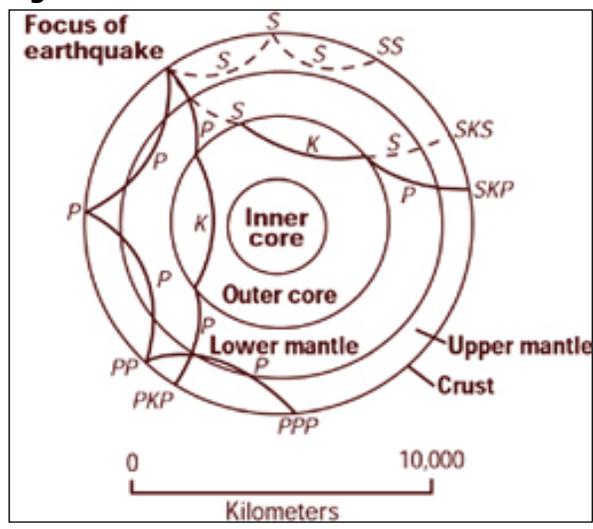
Figure 2



Why is the graph on the left (Fig. 2) so complicated?

Although students may be familiar with the basic body-wave phases of P and S, the travel time curve on the left plots many additional body wave phases. These occur because the original P and S wave energy gets reflected and refracted as it travels through the Earth. Each time a reflection or refraction occurs another letter is added to the phase name. The direct P arrival leaves the earthquake and travels directly through the mantle to the seismometer. The PP and pP arrivals, on the other hand, involve a reflection of energy from the surface of the Earth and arrive *after* the direct P wave arrival. The distinction between PP and pP is that for pP the seismic wave is initially upgoing from the focus for the surface reflection. Some of these are shown on the figure at lower left.

Figure 3



Station A receives *three* types of P waves. **Station B**, located half way between Station A and the epicenter, receives only the direct P wave in this three-path scenario. The PP refers to the entire path to **Station A** that gets reflected at the surface.

