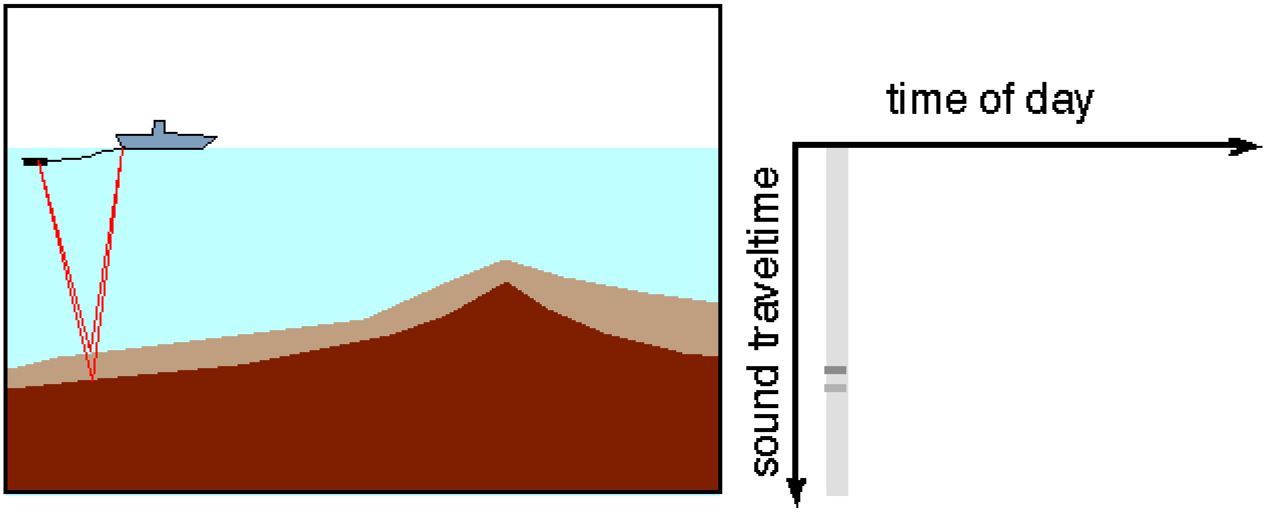
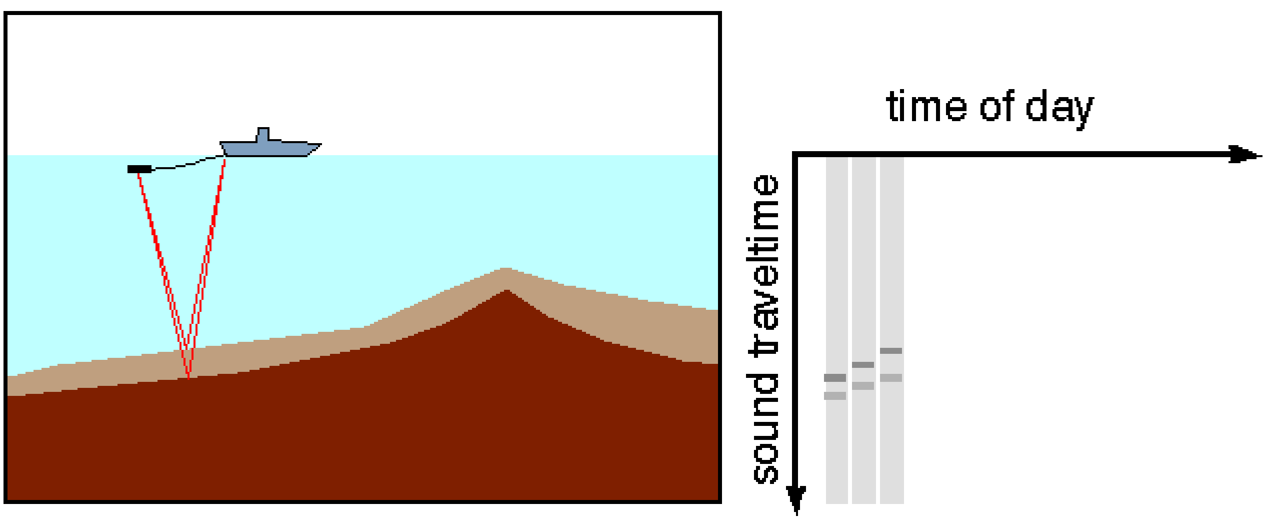
Seismic Reflection Profiling Tutorial

Seismic Reflection Profiling is a widely-used technique for using sound waves to image underground rock strata. It is widely-used by earth scientists, and plays an important role in oil exploration. It can be performed on both land and sea. A marine example is given here.

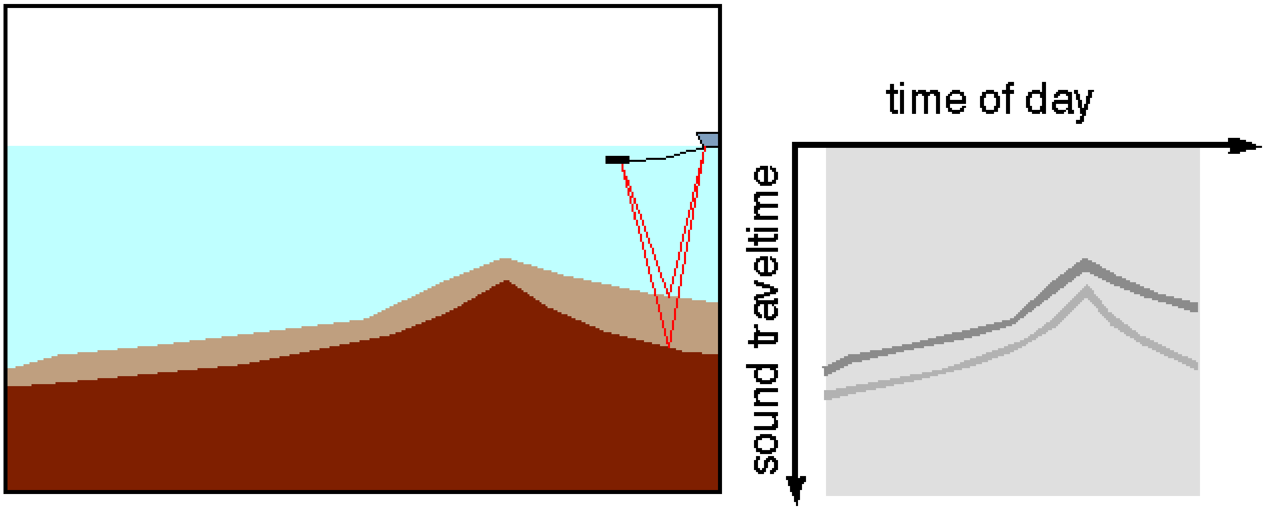


A sound wave (red line) is created by an "air gun" on the ship. The sound travels down through the water (blue), and penetrates into the layers of sediments (light brown) and rocks (dark brown) of the ocean floor. Some of this sound reflects (echos) off the layers, and travels back up to the surface of the ocean, where it is recorded by a hydrophone (black bar) trailed behind the ship.

The hydrophone (an underwater microphone) records the intensity of sound during the first several seconds after the air gun is is detonated. Sharp pulses of sound are detected when the pulses of reflected sound arrive. The sound intensity as a function of time is a grey stripe (right hand graph), with the most intense sound being the darkest grey. The tops of the two rock layers are clearly seen.



After 30-60 seconds, the air gun is detonated again, and the measurement and plotting process is repeated, with each stripe being drawn slighly to the right of previous stripes. Note that the time of the reflections is different, since the depth to the rock layers change as the ship moves.



After several hours, a complete image, or **seismic profile** of the seafloor is made. Note that this image differs from a true geological cross-section in several ways:

- Since it is the boundaries between the layers that reflect the sound (in contrast to the layers themselves), only the tops and bottom of the layers are visible.
- The horizontal scale of the image is time (corresponding to the movement of the ship), not distance. Any course or speed changes made by the ship are not apparent in the image. Of course, if the ship were moving at a constant speed, V, then distance could be computed as X=V*T, where T is time. (Ships typically move at speeds of 10-20 km/hr while making seismic profiles).
- The vertical scale of the image is time (corrseponding to the movement of the sound), not distance. Sound travels at quite different speeds in water (1.5 km/s), sediment (2-4 km/2) and rock (3-8 km/s), so that the shapes of features in the image may be considerably distorted. Various data processing techniques, not discussed here, are used for removing these distortions).

If a layer of rock in the image is T seconds thick, and if the rock has a sound velocity of V, then the true thickness is H=VT/2. The factor of 2 arises because the sound traverses the layer *twice*.