Amherst College
Geology 41: Environmental & Solid Earth Geophysics
Seismic Refraction Survey II

The purpose of this lab is to demonstrate how subsurface geology can be investigated through shallow refraction seismology. During this lab, we will conduct a seismic refraction survey outside on an area of "unknown" subsurface structure. This survey is meant to complement our previous gravity and electrical surveys

Successful analysis of the subsurface geology by refraction seismology depends on a relatively simple geometry to the subsurface geology. An ideal geometry would be to have a series of layers (either horizontal or inclined) each of which has a higher P-wave velocity than the overlying layer. In the area of our study, a possible subsurface geometry that would meet this requirement could have some or all of the following layers:

organic rich-soil	VP =	<0.5 km/sec
unsaturated glacial sediment		0.5-1.5 km/sec
water saturated glacial sediment		1.0-2.5 km/sec
Mesozoic sedimentary rock		2.5-4.5 km/sec
Paleozoic metamorphic rock		4.0-6.5 km/sec

In the field, we will set up a seismic refraction line with the geophones spaced 6 m apart. Data will be acquired for both forward and reversed lines. The shot points will be placed near the first geophone (6 m offset) and at some distance from the first geophone (long offset). We will collect data **two times** for each geometry for a total of 8 shots. Be sure to save the data on the computer AND to print out paper copies of each shot. Take notes to identify all of the files generated by your study.

1) For each of the shots (8 total), determine the travel time for the first break.

2) For each shot geometry (4 total), plot the travel time (y-axis) against distance (x-axis).

3) Examine each distance travel-time graph:

   Does the travel time increase linearly with distance from the shotpoint (i.e., do you have a straight line that passes through the shotpoint at travel time = 0)? If so, then the subsurface geology is homogeneous, the materials that we see at the surface are the same as those at some depth. From the slope of your travel-time graph, determine the seismic velocity of this material.

   Alternatively, does the travel time graph seem to be composed of a series of linear segments each with a progressively shallower slope? If so, then the subsurface geology is composed of a series of layers with progressively higher seismic velocities. From the slopes of each segment on your travel-time graph, determine the *apparent seismic velocities* of each layer.

Or, does the travel time graph have a different shape to it? If it does, describe the shape. The subsurface geology is complicated and not easy to interpret from refraction seismology.

4) Compare the results from all of the lines in your surveys:

Are the reciprocal times of the forward and reversed lines the same? If so, then you have probably done a good job picking first arrivals. If not, look carefully at the original seismograms.

Are the same apparent velocities of the forward and reversed lines the same? If so, then the layers are horizontal and the apparent velocities calculated above are the true seismic velocities.

Are the forward and reversed lines different? If so, this suggests that the interface is inclined. For an inclined interface, the up-dip apparent velocity is greater than the down-dip apparent velocity. Which direction is the interface dipping? Determine the true velocity of the lower layer and the dip of the interface.

$$\text{dip} = \frac{1}{2}\left[\arcsin\left(\frac{V_1}{V_{slow}}\right) - \arcsin\left(\frac{V_1}{V_{fast}}\right)\right]$$

$$V_2 = \frac{V_1}{\sin\left\{\frac{1}{2}\left[\arcsin\left(\frac{V_1}{V_{slow}}\right) + \arcsin\left(\frac{V_1}{V_{fast}}\right)\right]\right\}}$$

for shallow dips in which sin (dip) ≈ dip this equation reduces to:

$$\frac{1}{V_2} = \frac{1}{2}\left(\frac{1}{V_{slow}} + \frac{1}{V_{fast}}\right)$$

V_1- velocity above the interface

V_2- velocity below the interface

Calculate **delay times** for each refracted arrival. Using the delay time method, calculate the depth to the refracting horizon beneath each geophone

5) Based on the seismic velocities you determined what are likely geological candidates for each of your layers?