

NJCU Field Geophysics Assignment Collection 081106

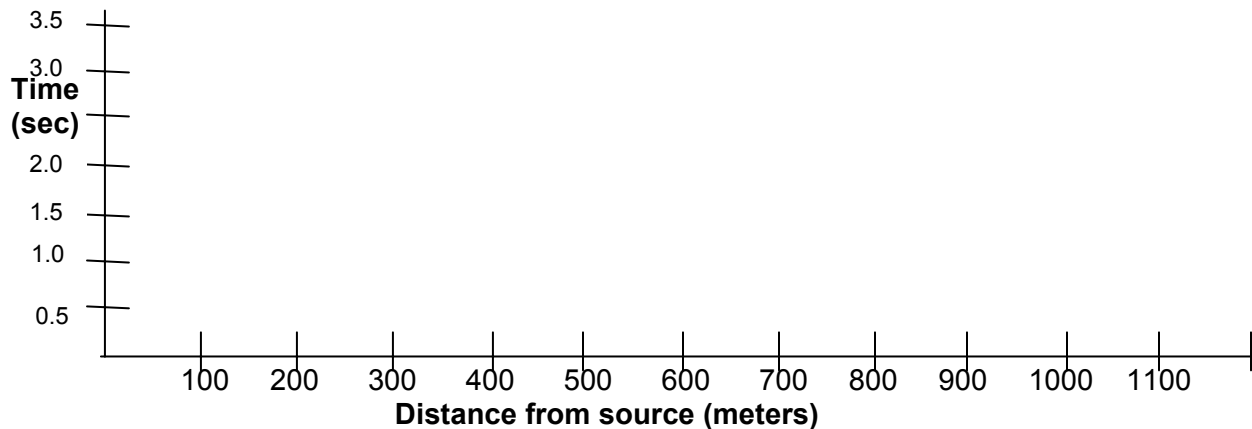
Asst01 – Constructing “time-distance” plots in materials with different velocity 30 pts

Introduction - You and your friend Michele are at the Olympic-sized swimming pool (50 meters in length) at the local recreation center, attending a swimming meet. Michele is trying to explain a basic geophysical principle of velocity to you: the MATERIAL through which sound travels controls the velocity at which the wave travels. This is a little confusing because some waves, such as light, have their own inherent velocity, independent of the material in which they travel.

The scenario – Desperately trying to get her point across to you, Michele jumps into the pool, yells at the starter at the opposite end of the pool to fire the starting gun, and then tells you to give her the “thumbs up” when you HEAR the gunshot. She says she will do likewise to you, then she buries her head underwater as the gun goes off.

The calculations –

- First, take an educated guess (hypothesis) as to who will give the “thumbs up” first, you or Michele. Give at least one reason for your hypothesis (5 pts).
- Next, look up the velocity of sound in air and in water (use Google or another internet search engine). (5 pts)
- Using the equation $\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$, calculate the amount of **time** it took the gunshot to reach your ears (t_{air}) and Michele’s ears (t_{water}). (10 pts)
- Create a time-distance plot (time on y-axis, distance on x-axis) for both the velocity of sound in air (V_{air}) and velocity of sound in water (V_{water}), extending to 1000m (10 pts)

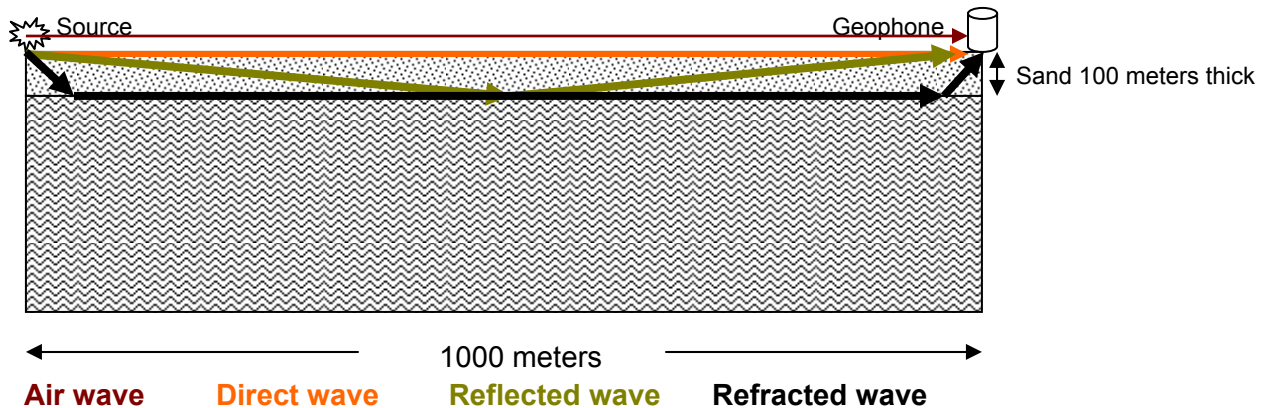


Due approximately one week from the assignment date. Check your syllabus.

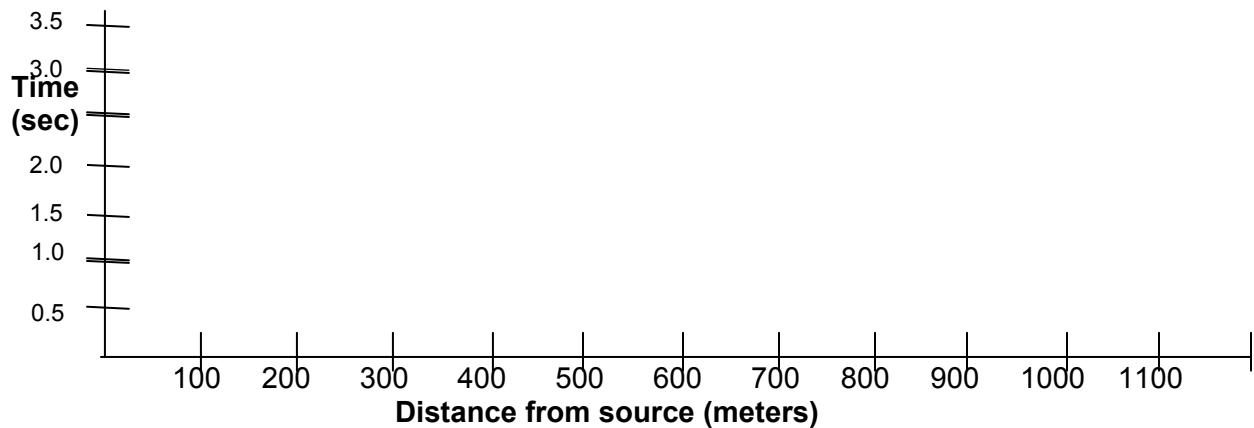
Asst02 – Computing and comparing travel times of different ray paths 30 pts

Introduction – In Asst 01, you learned that the medium through which an acoustic (aka “sound”) wave travels controls its velocity. Now it is time to explore the different travel paths that the sound from one source travels on its way to your ear or other listening device, such as a geophone. Think of a geophone as like a microphone, but instead of picking up sound waves from your mouth, the geophone picks up sound waves from the Earth.

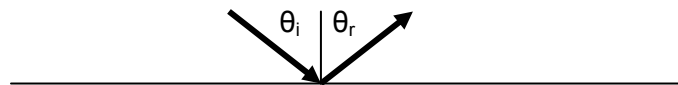
The scenario – Your friend Melissa is pounding a sledgehammer on a steel plate that is sending sound waves toward a geophone, as shown below. Assume that the subsurface consists of 2 different layers: 100 meters of sand ($V = 1000$ m/sec) overlying granite bedrock (5000 m/sec). The picture below (not necessarily to scale) diagrams how the ray paths from the source could travel 4 different ways to a geophone: air wave, direct wave, reflected wave, refracted wave:



The calculations – For this assignment, you will calculate (show your work for full credit) the time it takes for each of these waves (air wave 5 pts, direct wave 5 pts, reflected wave 10 pts, refracted wave 10 pts) to reach the geophone and plot each point on the graph below:

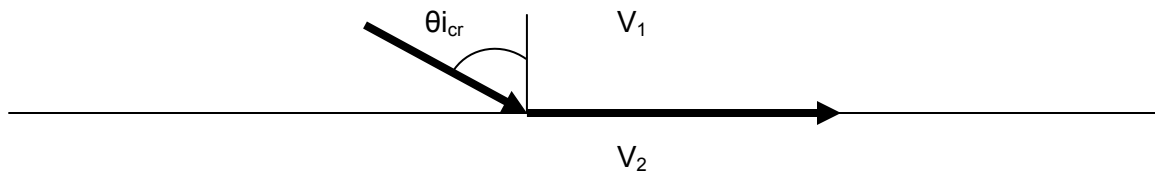


Note that you will have to perform some basic trigonometry in order to calculate the reflected and refracted waves. The reflected wave will obey the rule that the angle of incidence equals the angle of reflection, as measured from the perpendicular to the reflection surface as below:



The refracted wave will refract from the sand at the “critical angle” ($\theta_{i_{cr}}$) into the granite and travel along surface of the granite, exiting at the critical angle from the granite into sand and then to the geophone. This is diagrammed in the first figure. The geometry of the refracted ray path is controlled by this equation:

$$\theta_{i_{cr}} = \sin^{-1} \left(\frac{V_1}{V_2} \right), \text{ where } V_1 \text{ is the velocity of the material above the interface, and } V_2 \text{ is the velocity of the material below the interface, as shown below:}$$



The term \sin^{-1} is also referred to as “arcsine” and can be better understood by substituting these words in place of the term: “**the angle whose sine is**”. For example, in this case, if $V_1 = 1000$ m/sec and $V_2 = 5000$ m/sec, $\theta_{i_{cr}}$ is the angle “whose sine is” $1000 / 5000 = 0.20$. By using a calculator or consulting a trig table, you can easily determine this angle.

You may find it helpful to construct a true-to-scale diagram for this exercise, which will enable you to use a protractor and measure (or check) the angles of the reflected and refracted waves.

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Asst 03 – Pick arrival times, calculate velocities & depths, create a cross-section 40 pts
Introduction – This assignment is essentially Problem 3.2 of the Burger et al. text. It uses a field seismogram in Fig. 3-41, reproduced below for convenience and accuracy. The distances are for geophones at set intervals (in meters) from the source, while time (in milliseconds [.001 sec = 1 msec]) is the time it takes for the wave to reach a geophone.

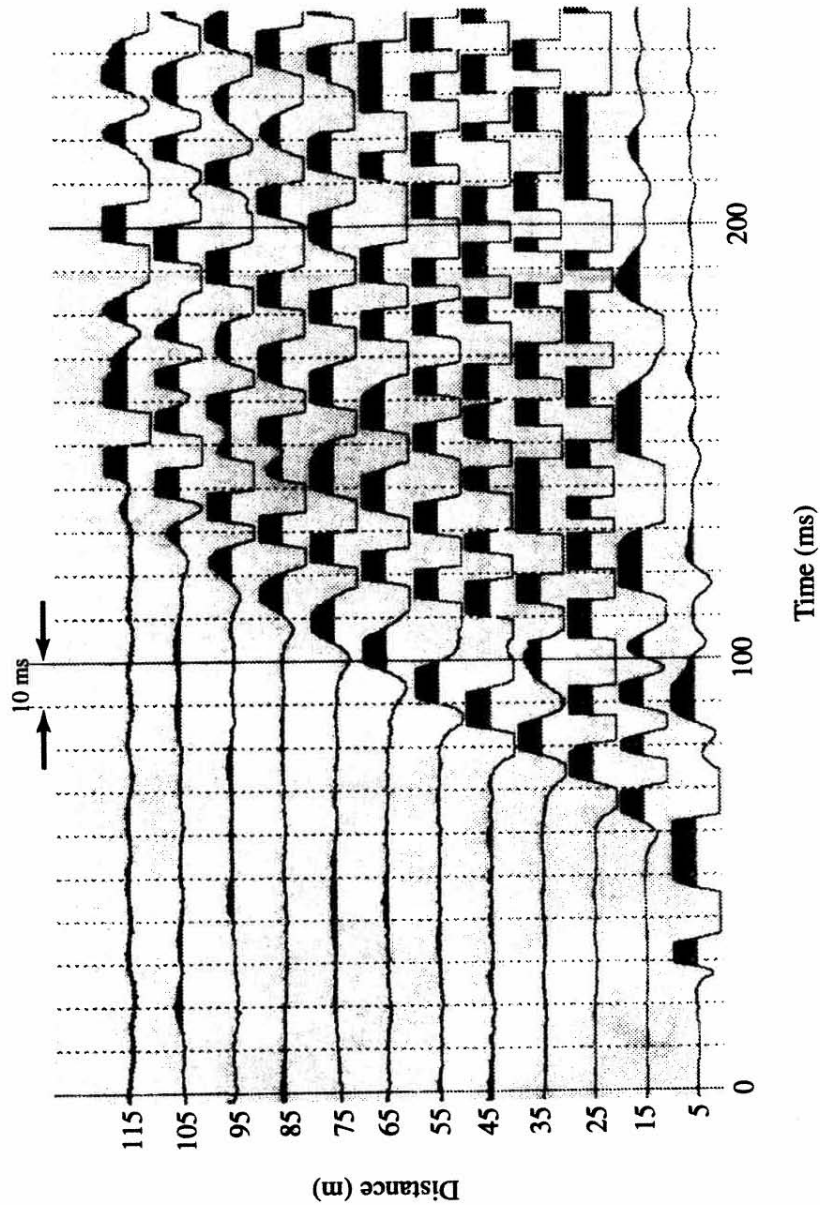
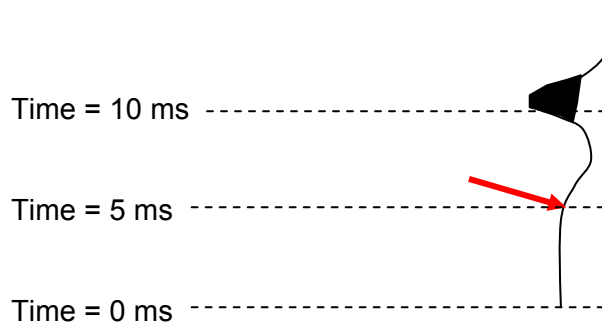


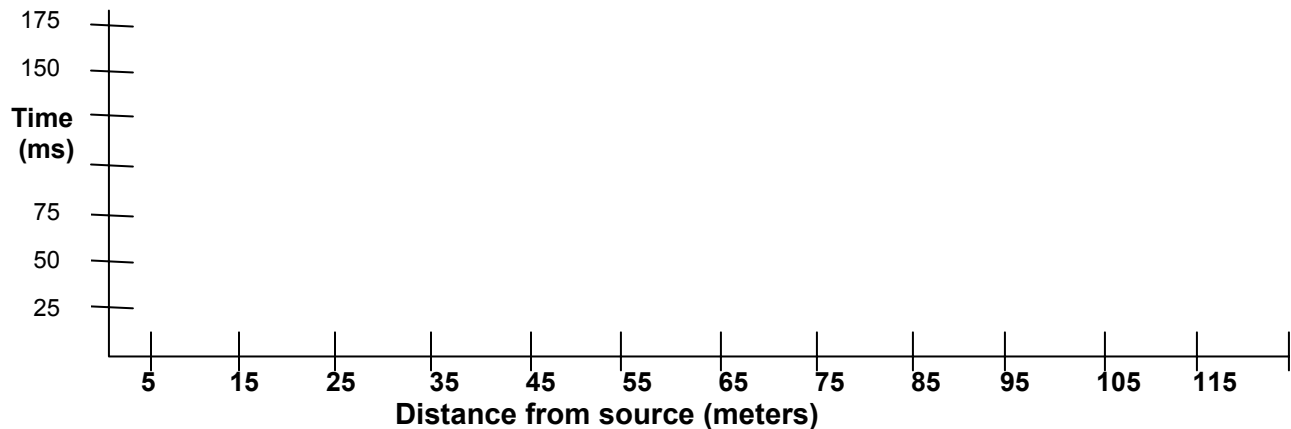
FIGURE 3.41 Field seismogram for Problem 3.2.

The scenario – You are only concerned with the first “arrival” at each geophone. For this exercise, it is suggested that you make the “pick” of the first arrival when the line begins to bend away from a straight line. The first arrival is at 5 milliseconds in the example below:



The calculations –

a) First, create a travel-time vs distance graph based upon your first arrival picks (10 pts).



b) Second, create as many straight-line segments as are necessary to “fit” the curve (10 pts). Each straight-line segment represents the velocity ($\Delta d/\Delta t$) of a subsurface layer through which the seismic wave traveled. Draw each straight line by sighting along your graph at a shallow angle, then determine the approximate velocity of each layer. It is suggested that you “ink” your points first, then use pencil to draw your line segments. Make sure you project your line segment(s) all the way back to the “Y” axis of your graph (the surface layer will intersect the y axis at $t=0$, but the rest of the line segments will intersect the Y-axis higher up (t_i in the equation below). You will use these Y-axis crossings in the next step.

c) Third, create a simple cross-section of the subsurface by calculating the depth to each interface (10 pts). You can do this because 1) you know the **velocity** of each layer through which seismic energy is passing, and 2) you have an estimate of the **time** that it would take for that interface to be reached directly below the source at the position of the Y-axis. You will use the following equation:

$$h_1 = \frac{t_i}{2} \frac{(V_2 V_1)}{\sqrt{(V_2^2 - V_1^2)}}, \quad \text{where } h_1 \text{ is the thickness of layer 1}$$

d) Fourth, consult a geoscience reference (e.g., geophysics textbook, the Web, etc.) to link your calculated velocities with possible sediment or rock types (e.g., soil, granite). Label your cross section layers with both velocities and the possible sediment or rock type of each layer (10 pts). Since there is overlap in seismic velocities, this requires interpretation.

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