Refraction Seismology Experiment

Earth Forces

due February 22, 2008

Objective: To explore the shallow subsurface using a small-scale seismic refraction experiment, and to familiarize students with simple seismic data acquisition and interpretation.

Procedure:

1. Lay out experiment with a long measuring tape extending in the direction of the geophone spread. Place the striker plate near the start of the measuring tape. Uncoil spread cable and extend along the tape, with take-outs spaced with the desired geophone interval. The strike plate will be at meter 0, the first geophone should be at 2 meters distance. Space the geophones at 2 meter spacing up through 48 meters distance. Connect the geophones to the take-outs by matching the wide clip to the wide gap in the take-out. Put the geophones firmly into the ground (step on them). Be sure the geophones go vertically into the ground and do not touch the measuring tape.

2. Be sure to record important data such as the position of the line (GPS location), the orientation of the line, and geophone spacing and shotpoint locations relative to the geophones.

3. Connect the spread cable, hammer switch, power supply, and laptop computer to the seismograph. The seismograph is a 24 channel Geometrics Geode. Its operation will be demonstrated in the lab. After connecting all the geophones, we will check the noise monitor to make sure all the geophones are operating. At this point somebody should check to make sure all the geophone positions are correct.

4. One person wearing the ear protectors will strike the sledge hammer against the striker plate. The waveforms from each geophone will be displayed on the laptop screen. If the signals are not clean (for example, if the hammer strike was not good or if a gust of wind causes a lot of noise on the record) the signal can be erased. Noise will be minimized by "stacking", or adding the signals of several hammer blows, which generally causes random noise to cancel out but enhances the true signal. If the record is good it will be added into memory.

After enough good hammer blows are added, the data is complete, and will be stored in the computer.

5. Now repeat the procedure for the reverse profile. (repeat steps 3-5 from the other end of the geophone line (48 m point).

6. Help pack up the equipment and proceed back to Wilson Hall. You will be given plots of all the data produced, and the data will be on some of the computers in the lab if you want to do more detailed picks.

Data Analysis:

Produce a model for the shallow structure of the study area based on the data you have obtained. You may want to graph the results on a computer and do linear interpolation to find the slopes and intercepts. For a flat 2-layer structure you should use the formulas we derived in class.

Dipping Layer: To account for a dipping layer, you must first analyze the forward and reverse profiles as you would in the flat layer case, obtaining the velocity V_0 (which should be the same for both profiles) and the slope and intercept for the second layer for both the updip (m_u , T_u) and downdip (m_d , T_d) profiles (the updip slope will be less than the downdip slope). The dip of the layer in the direction of the profile is then:

$$\alpha = 0.5(\sin^{-1}(V_0 m_d) - \sin^{-1}(V_0 m_u))$$

and the critical angle for refraction is:

$$\theta = 0.5(\sin^{-1}(V_0 m_d) + \sin^{-1}(V_0 m_u))$$

The actual velocity in the lower layer is then:

$$V_1 = V_0 / \sin\theta$$

and the depths to the interface below the updip and downdip ends of the profile (z_u and z_d) are:

$$z_u = V_0 T_u / (2 \cos\theta \cos\alpha)$$

$$z_d = V_0 T_d / (2 \cos \theta \cos \alpha)$$

3 horizontal layers: For three layers the velocities of each layer (V_0, V_1, andV_2) and the depth to the first interface (z_0) are determined exactly as they are for the 2 layer case. The depth to the second interface is determined from:

$$z_1 = z_0 + 0.5 (T_2 - 2z_0(V_2^2 - V_0^2)^{0.5}/V_2V_0)(V_2V_1/(V_2^2 - V_1^2)^{0.5})$$

where T_2 is the y-intercept of the line with slope $1/V_2$.

Questions:

1) What is the approximate velocity of the air wave and the ground roll?

2) Calculate the arrival time of the reflection from the first interface at various offsets. Can you observe it on the records? Why or why not?

3) What material do you think makes up the second layer (and third, if you found 3 layers) ?

Hand in:

1) Copies of seismic records with the direct and refracted arrivals marked, as well as the air wave and ground roll (surface waves).

2) Complete analysis procedure, including graphs. Follow the format in the lab writup handout. Include the answers to the questions in the write up.