Seismic Processing
Prac 3 - Review Questions

ERTH3021

October 21, 2014

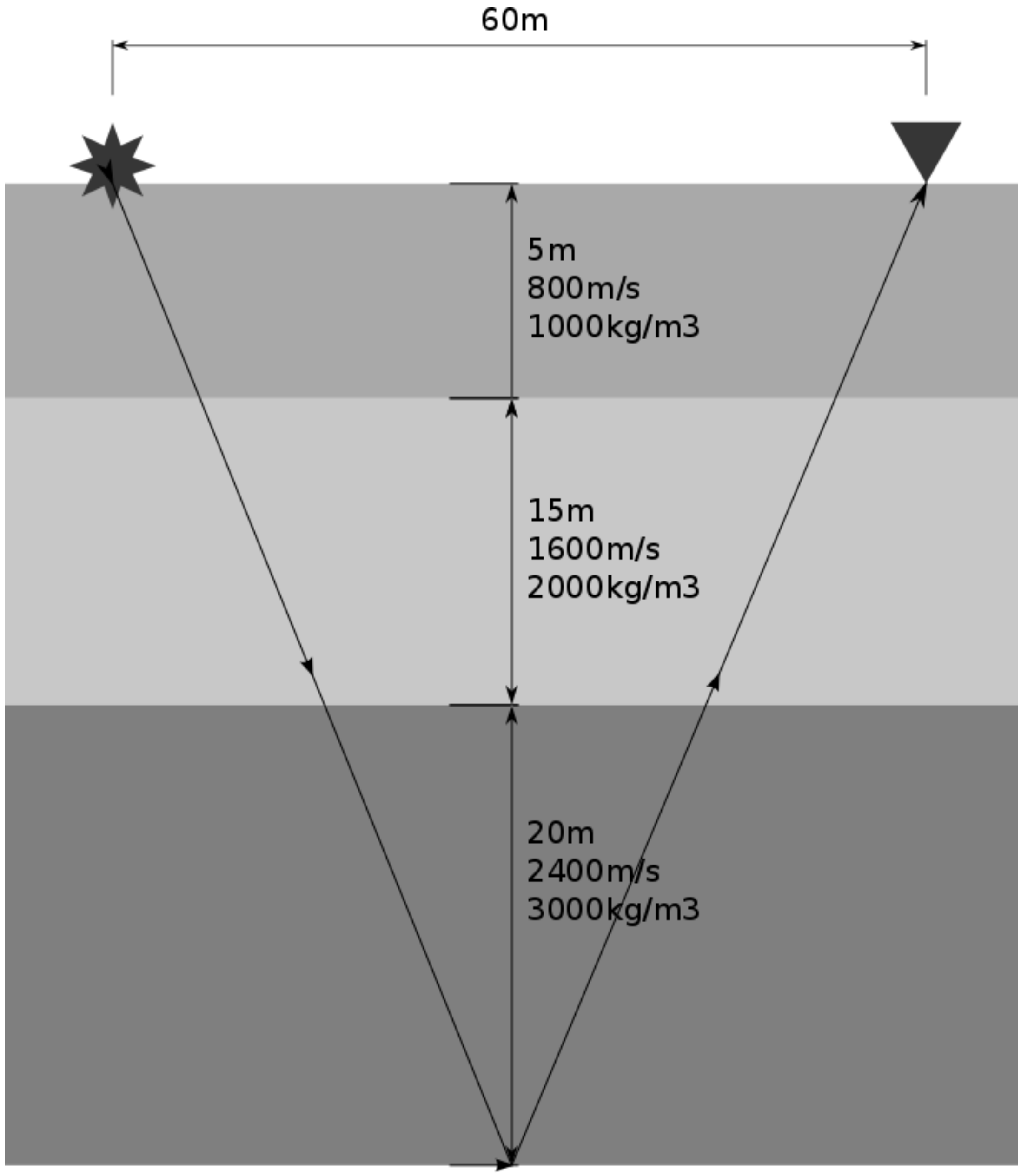

Figure 1: Seismic Model. The star is the source location and the triangle a geophone. This model assumes straight rays.

1 The Convolutional Model

1.1

Describe in words what convolution is, and how it differs from correlation. Give an example of where you might use a) convolution and b) correlation.

1.2

The convolutional model of the seismic trace states that the trace we record is the result of the earth's response convolved with the source wavelet and the recording system, with some additional noise. Show an equation which describes this, and label each term.

1.3

The earth's response consists of a range of different signals, including the direct wave, refracted wave and reflected wave. Modify the convolutional model equation to include these signals.

2 The Direct Wave

2.1

What is the direct wave?

2.2

Assuming a velocity of 400m/s, how long does it take the direct wave to travel from the source to receiver shown in Figure 1?

2.3

Attenuation of waves occurs for a number of reasons. One reason is that of spherical divergence. Describe the basic cause of amplitude loss due to spherical divergence.

2.4

Briefly discuss one other cause of wave attenuation in seismic data.

2.5

Assuming that the attenuation due to spherical divergence has a coefficient of two, and the source has unit amplitude, calculate the amplitude of the direct wave at the geophone in Figure 1.

3 The Refracted Wave

3.1

What is a refracted wave? What is one potential use of the refracted wave data?

3.2

What is the critical angle at the bottom of the first layer in the source-receiver geometry shown in Figure 1?

3.3

What is the travel time for the geometry shown in Figure 1?

4 The Reflected Wave

4.1

Calculate the travel time of the reflected wave for the model shown in Figure 1. Assume straight rays.

4.2

Discuss how you would analytically calculate the correct (non-straight) ray path.

4.3

Assuming a unit source amplitude, calculate the amplitude of the reflected wave at the geophone due to transmission and reflection coefficients. Assume zero offset coefficients.

Discuss when it might and might not be appropriate to use the zero offset assumption.

5 Seismic Gathers

5.1

What is the difference between a shot gather, a receiver gather and CMP gather? Draw a rough diagram of each.

5.2

What are CMP gathers useful for? Why?

5.3

What assumptions are made when CMP stacking? What happens when these assumptions break down?

5.4

What is fold?

6 Amplitude Recovery

6.1

Why is amplitude recovery used?

6.2

Why is using an AGC for amplitude recovery not ideal?

7 Normal Moveout

7.1

Draw a rough diagram showing why normal moveout is hyperbolic.

7.2

Calculate the zero offset travel-time for the reflection event in question 4.

7.3

Wavelet stretching is caused by the non-linear NMO correction. Discuss the impact of stretch and a potential mitigation strategy.

8 Stacking

8.1

What is stacking?

8.2

What is the signal to noise ratio improvement for a CMP gather with a fold of n?

9 Noise attenuation

9.1

The refracted wave calculated in question 3 is often considered noise. What is one method that can be used to remove the refracted wave? Discuss the steps required in this method.

9.2

Often we want to enhance coherent events whilst attenuating random events. Discuss one method for achieving this. Discuss the potential negatives associated with this method.

10 Processing Flows

10.1

Suggest a simple processing flow for a seismic dataset, using the processes discussed from question 5 to question 9. State why you chose that particular processing sequence. State any key parameters which need to be tested.

11 Useful Formulas

$$R = \frac{1}{distance^2}$$

$$T = \frac{X}{V_1} + \frac{2z\cos i_c}{V_0}, \quad i_c = \sin^{-1}\frac{V_0}{V_1}$$

Where

- X = lateral distance
- V_0 = velocity of weathering layer
- V_1 = velocity of sub-weathering layer
- z = thickness of weathering layer
- i_c = critical angle

$$R_r = \frac{z_1 - z_0}{z_1 + z_0}$$

$$R_t = \frac{2 * z_0}{z_1 + z_0}$$

where

- z_0 = acoustic contrast in layer 0, i.e. $\rho_0 v_0$
- z_1 = acoustic contrast in layer 1, i.e. $\rho_1 v_1$

$$t_x{}^2 = t_0{}^2 + \frac{x^2}{v^2}$$

where

- t_x is the travel time at offset x
- t_0 is the travel-time at offset 0
- x is the offset
- v is the velocity