Introduction to Earthquake Seismology
Assignment 18

Department of Earth and Atmospheric Sciences **EASA-462**
Instructor: Robert B. Herrmann **Office Hours: By appointment**
Office: O'Neil Hall 203 **Email: rbh@eas.slu.edu**
Tel: 314 977 3120

Surface Waves

Goals:

- Determination of phase velocity
- Determination of group velocity
- Determination of average crustal thickness

Background:

On September 28, 2004 a moment magnitude 6.0 earthquake occurred at PArkfield, California. The event coordinates were OT 17:15:24, 35.82°N, 120.37°W, and depth 7.9 km. The US Geological Survey's National Earthquake Information Center had observations to distances of 150°. This earthquake generated well recorded surface waves.

For this exercise we will consider the surface waves propagating from the earthquake to two seismograph stations operated by Saint Louis University: FVM (French Village, MO) and USIN (University of Southern Indiana). Figure 1 shows the location of the earthquake and stations while Figure 2 shows the vertical component seismograms. Figure 3 shows an expanded view of the signal that focuses on the surface wave.

The distances and azimuths from the earthquake to the stations are as follow:

Station	Distance (km)	Arc Distance (de)	Azimuth (°)
FVM	2668.5	24.00	75.8
USIN	2910.3	26.17	75.4

The fact that both stations are on a great circle path is important so that both sample exactly the same radiation from the source.

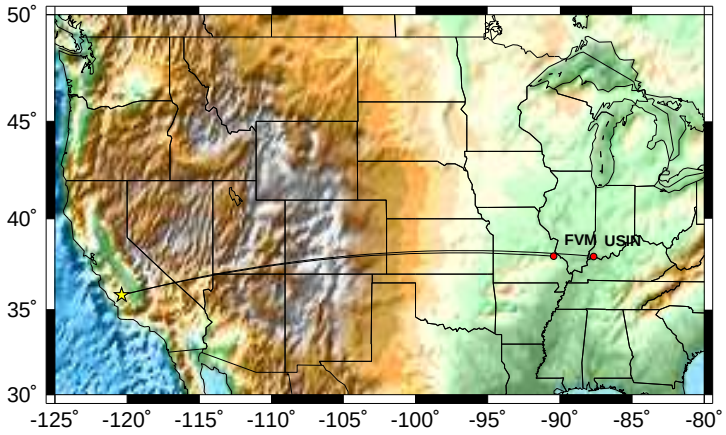


Fig. 1. Location of the Parkfield earhtquake and the two seismograph staions. Thje arc connecting the earthquake to the seismograph stations is the great circle path.

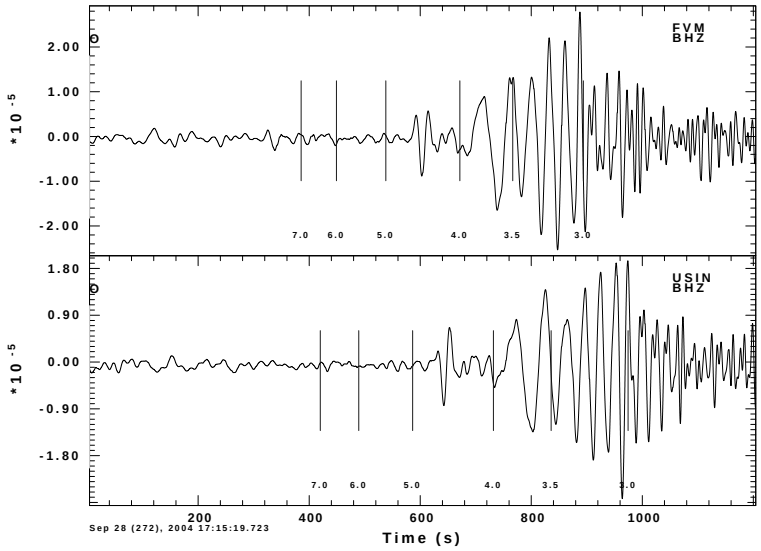


Fig. 2. Vertical component seismograms. The trace starts at the earthquake origin time until 1200 seconds after the earthquake. The raw traces were filtered using a 2-pole, 2-pass Butterworh high-pass fitler at 0.01 Hz, a one-pole 2-pass Butterowrth lowpass filter at 0.1 Hz and integrated to present a lowpassed image of gound displacement. The usings are in *meters*.

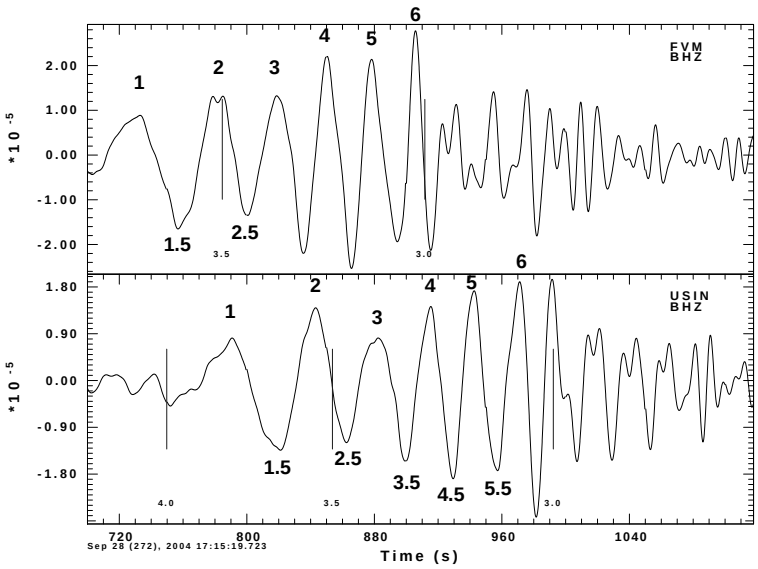


Fig. 3. Expanded view of Figure 2 that focuses on the Rayleigh-wave arrival. The tic marks and numbers indicate the group velocity from the source to a particular point on the trace. The numbers above the trace peaks are used to associate the corresponding peaks betweent he two stations.

The analyst has identified the surface wave on these recordings and has marked provide the arrival times of the peaks and troughs, as follows:

Index	FVM		USIN	
	Arrival Time	Travel Time	Arrival Time	Travel Time
1	17:27:13.9		17:28:11.9	
1.5	17:27:37.2		17:28:39.3	
2	17:28:03.2		17:29:03.9	
2.5	17:28:23.2		17:29:23.9	
3	17:28:39.9		17:29:42.7	
3.5	17:28:57.3		17:30:01.3	
4	17:29:11.3		17:30:17.3	
4.5	17:29:27.3		17:30:30.7	
5	17:29:39.9		17:30:44.1	
5.5	17:29:56.6		17:30:58.0	
6	17:30:07.3		17:31.12.7	
6.5	17:30:16.7		17:31:23.4	

What you must do:

1. Determine the group velocity from the earthquake to both stations. These values will describe the group velocity of the entire path, and the small additional path between FVM and USIN will not make much of a difference.
2. Determine the phase velocity between FVM and USIN

To determine these velocities, you must first determine the trace time corresping to each peak/trough index.

Group velocity

To determine the group velocity, do the following:

1. For each station separately, plot the travel time (y-axis) versus the peak/trough number (horizontal axis).
2. From the plot (or numebrs in the table), determine the slope (change travel time/integer change in peak number). This is the period for that peak/trough number
3. For that peak trough number, determine the group velocity, defined as the epcientral distance divided by the travel time.
4. Plot the group velocity as a function of period on the graph at the end of this assignment.

Phase velocity

To determine the phase velocity, do the following:

1. For each peak/trough number, determine the arrival time difference between the stations. The phase velocity is the inter-stationdistance divided by ttravel time difference.
2. Define the period of this observation (this is the average of the periods determined for the same peak/trough index that you determined for the group velocity. Because of the dispersion the period associate with peak 1 will be slightly greater at USIN than at FVM.
3. Plot the phase velocity as a function of period on the phase velocity graph paper

What you must submit:

1. The tabulations and plots of the pahse and group velocity dispersion.
2. An estimate of the crustal thicknesses. This is done by comparing measured dispersion to the theoretical curves which are also plotted on the graph paper. These curves correspond to a velocity model with the parameters

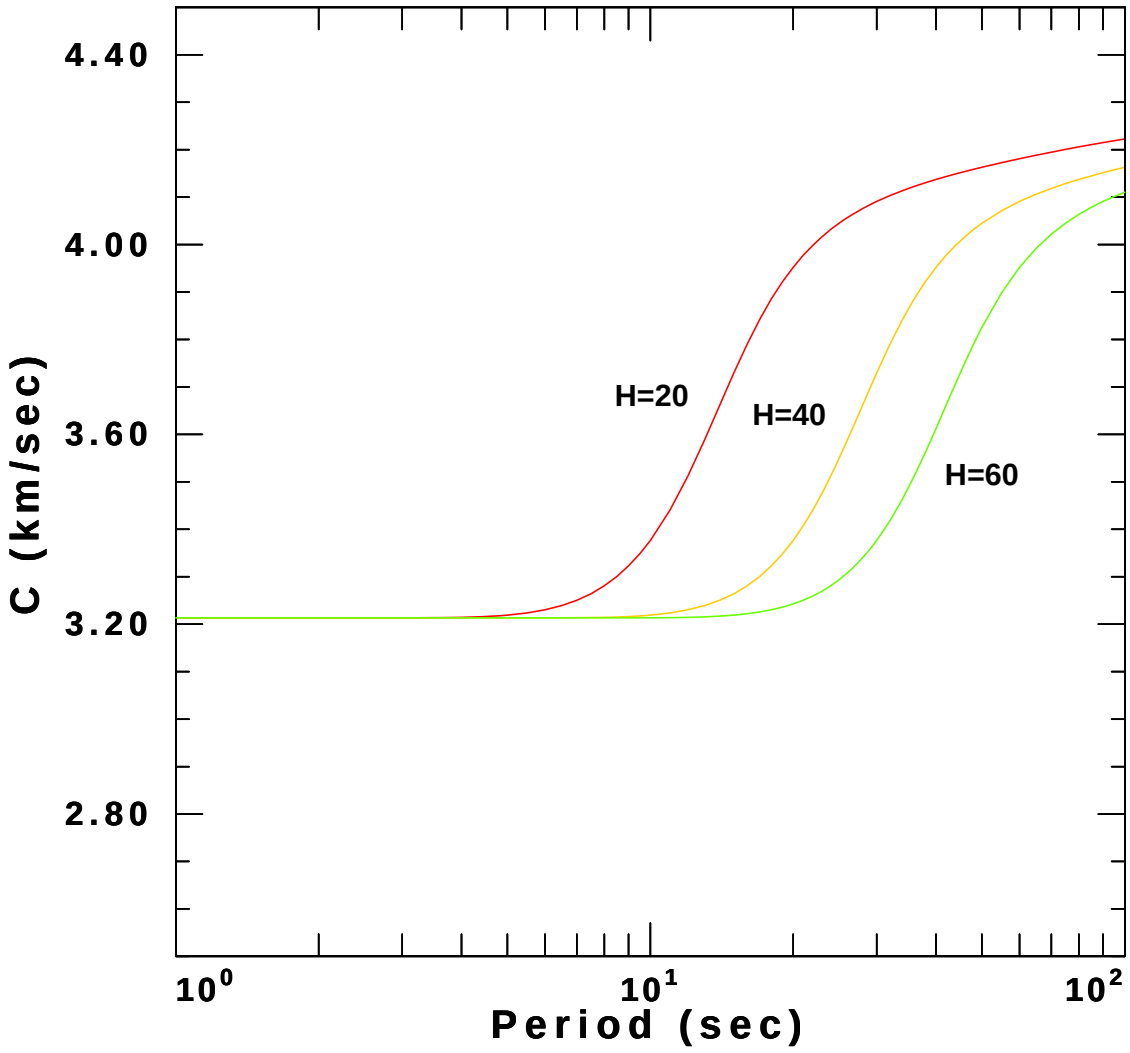
H (km)	V_P (km/s)	V_S (km/s)	Density (gm/cmu3)
H	6.0	3.5	2.7
-	8.0	4.7	3.3

with the layer thickness H=20, 40 and 60 km.

a) For the California to station path, use the group velocity dispersion to estimate the average crustal thickness

b) for the FVM-USIN, use the phase velocity dispersion to estiamte the crustal thickness.

Rayleigh Phase Velocity



Rayleigh Group Velocity