

Assignment 5 - Seismology

Name _____

Strait of Georgia earthquake - June 24th, 1997

Introduction:

At approximately 7:40 AM on the 24th of June 1997 a significant minor earthquake occurred in the Strait of Georgia. The quake was felt all along the east coast of Vancouver Island, from Campbell River to Victoria, all around Vancouver and up the Fraser Valley as far east as Abbotsford.

There were two reports of minor damage in the Vancouver area, including a broken water pipe and broken glass. Power was lost in Sechelt and Port Alberni because BC Hydro motion-sensitive switches were tripped. The greatest Mercalli intensity associated with this earthquake was IV - which means that although the damage was negligible. It was felt by most people indoors.

There was a magnitude 3.4 earthquake at the same location 11 days earlier. Taimi Mulder of the Geological Survey of Canada's Pacific Geoscience Centre in Sidney has provided the information, and the seismograms given here. For more information on this topic visit the PGC website at: http://earthquakescanada.nrcan.gc.ca/index_e.php

Instructions

Location of the June 24th earthquake

Seismograms from several stations on the mainland and Vancouver Island are included at the end of this section. Following the example given on Figure 10.2, pick the arrival times for the P and S waves associated with this earthquake. Do this for each of the stations (NAB, BIB, WPB), and record the information in columns 1 and 2 of the table below. Use those values to calculate the S-P times, and record these in column 3.

In these seismograms the P-wave arrivals are easy to see because the background signals are essentially flat. The S-wave arrivals are more difficult because at this close range to the earthquake there were still significant vibrations from the P waves when the S waves came in. Try to pick your S arrival as the first peak, which is significantly higher (or lower) than the background noise from the P waves.

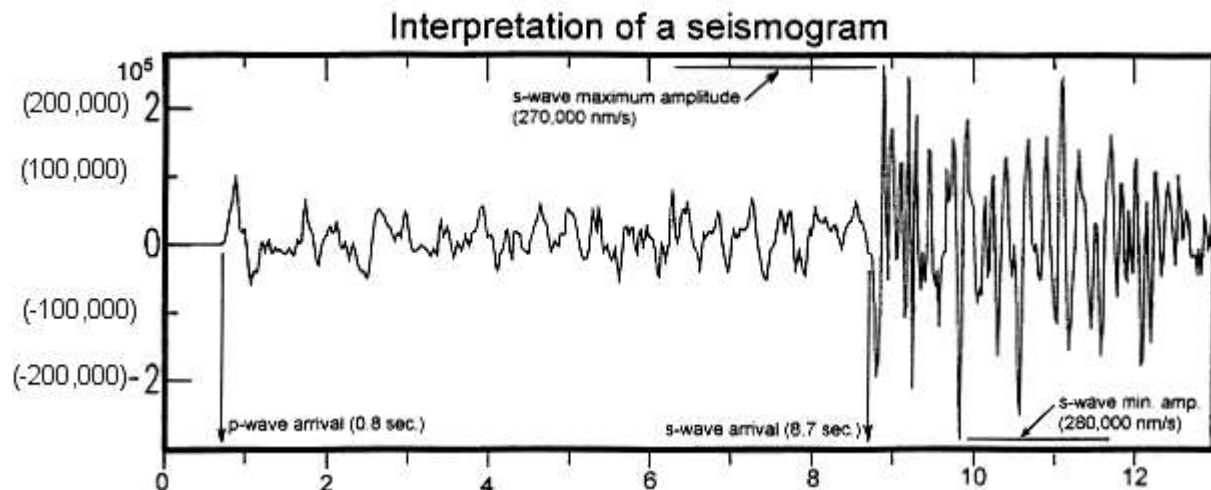


Figure 10.2

The distance from the epicentre to a seismic station can be estimated from the S-P time interval using a series of mathematical formulae, or a time-distance graph like the one shown on Figure 10.18 of the textbook (p. 284). This diagram is not useful for this earthquake, however, because it does not give enough detail for relatively short travel times.

A graph of P-S times versus distance for the June 24th earthquake is included here as Figure 10.3. While the relationship between P-S times and distance is not linear over large distances, it is close to linear over short distances, and this linear graph should give good results.

If you prefer, the following formula will also work:

$$D = (T_{S-P} \times 9.3) - 8.5 \text{ (where } D = \text{the distance in km, and } T_{S-P} \text{ is the S-P time),}$$

but be aware that this formula only applies to this earthquake, and only for the range of S-P times shown on Figure 10.3.

Figure 10.3

Use the graph (or the formula) to estimate distances for at least 6 of the stations and record the values in column 5. For example, a S-P time of 6.5 seconds is equivalent to a distance of 52 km - as shown on the graph.

Using a compass (and the distance scale provided on the map) draw circles around the stations shown on Figure 10.5 (see Figure 10.18 in the textbook). The epicentre of the June 24th earthquake should be near to the point where most of the circles intersect.

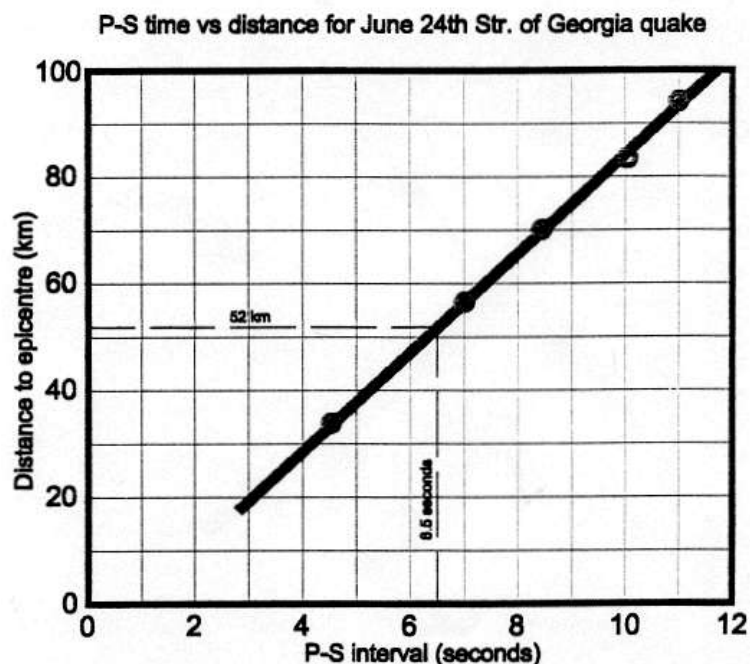
Don't expect perfect intersections, but if some of your circles don't intersect as closely as you would like, take a second look at the seismograms to see if you can get better estimates of the P and S arrival times. If the solution still doesn't fit, then you should exclude the inconsistent results from your final determination.

In determining the location of an earthquake it is important to use data from stations, which are situated at various points around the epicentre (i.e. not all on one side). Now that you have a good idea where the epicentre was, choose at least four stations which are well positioned for this location, and in which you have confidence in your arrival picks, and use those to determine your best location for this event. Mark that location on Figure 10.5.

Magnitude of the June 24th earthquake

The "Richter scale" magnitude of an earthquake is determined from the maximum amplitude of the secondary waves and the distance from the station to the epicentre. In these seismograms amplitudes are expressed as the velocity of ground motion at the seismic station (in nm/s or 10^{-9} metres per second).

Determine the maximum and minimum velocity of the ground motion by estimating the values for the highest peak and the lowest peak (see Figure 10.2) and then taking the average.



Note that the vertical scales on the seismograms for the different stations need to be multiplied by either 10^5 or 10^6 , as shown. For the example seismogram (Figure 10.2) the highest level is close to 270,000 (2.7×10^5) and the lowest level is close to 280,000 (its actually -280,000, but express it as 280,000). The average is 275,000.

Convert from velocity (nm/s) to amplitude (mm) using the following formula:

$$\text{Amplitude (mm) [Column 6]} = \text{Velocity (nm/s) [Column 4]} \times 0.000064$$

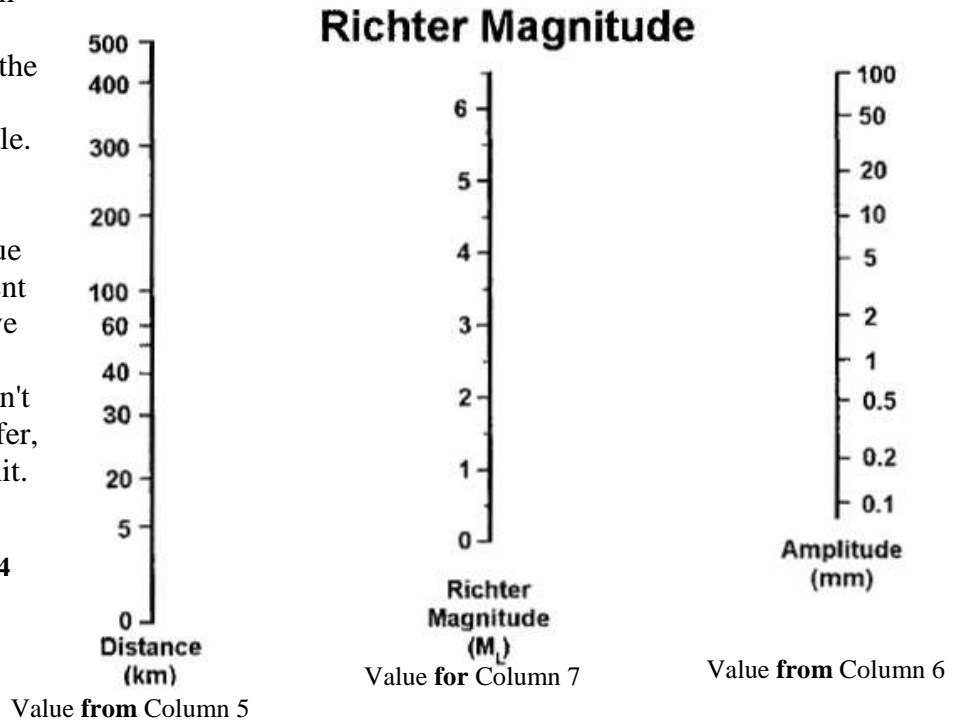
(which gives a value of 17.6 mm for the example). The constant 0.000064 represents the elastic properties of the rocks through which the seismic waves have propagated. This value is arrived at from long-term observations in our area.

Estimate the amplitude for at least three of the stations and record the values in column 6.

A graph for determining Richter magnitude from seismogram amplitude is given on Figure 10.4.

To determine the magnitude from each of your selected stations hold a ruler at the level of the appropriate amplitude (in mm) on the right hand scale and at the level of the appropriate distance (in km) on the left-hand scale. Read the Richter magnitude on the centre scale and record the value in column 6. The different seismograms will all give slightly different magnitude values; so don't worry if your results differ, even by as much as 1 unit.

Figure 10.4



Procedure:

Using the procedure summarized below fill in the blanks in the table.

Step 1: pick arrival times for P and S waves [Columns 1 and 2]

Step 2: calculate difference in arrival times [Column 3]

Step 3: convert difference in arrival times into distance from epicentre [Figure 10.3]

Step 4: draw circles on map [Figure 10.5], determine location of the epicentre

Step 5: average the maximum and minimum amplitude velocity for Column 4

Step 6: convert the velocity to amplitude using the equation on page 10-3

Step 7: convert amplitudes and distance to Richter magnitude using Figure 10.4

		1	2	3	4	5	6	7
Station	Location	P (sec)	S (sec)	S-P (sec)	Velocity (nm/sec)	Distance (km)	Amplitude (mm)	Richter Magnitude
NAB	Nanaimo							
BIB	Bowen Is.							
WPB	Howe Sd.							
SNB	Saturna Is.							
HNB	Haney							
MGB	Mt. Grey							
VGZ	Victoria							
PFB	Pt. Renfrew							

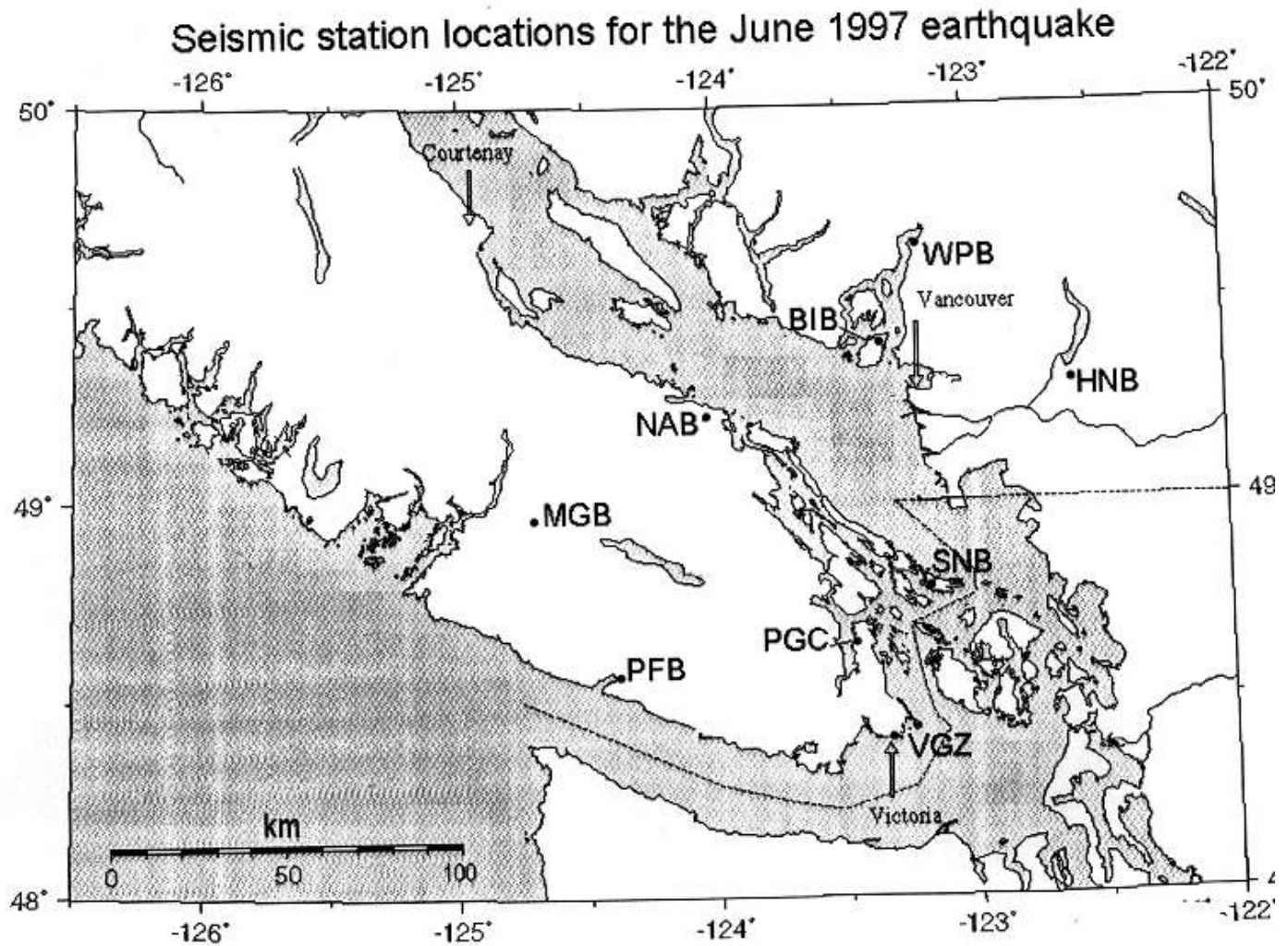


Figure 10.5

