

**Problem Set #5**  
**Volcanoes! Earthquakes! OH NO!**  
12.102/ Due Nov. 15

As it turns out, you of all people have been hired to do a volcanic hazard assessment for Mt. Rainier, Washington. There is much talk about the horrible hazards that await the inhabitants of Washington State due to its precarious position above the Cascadia Subduction Zone. Naturally, insurance companies want to know what areas are in the greatest danger so that they can plan accordingly for future volcanic eruptions or earthquakes. The purpose of this exercise is to introduce you the many considerations that must be taken into account when doing such a study by focusing on the hazards associated with Mt. Rainier.

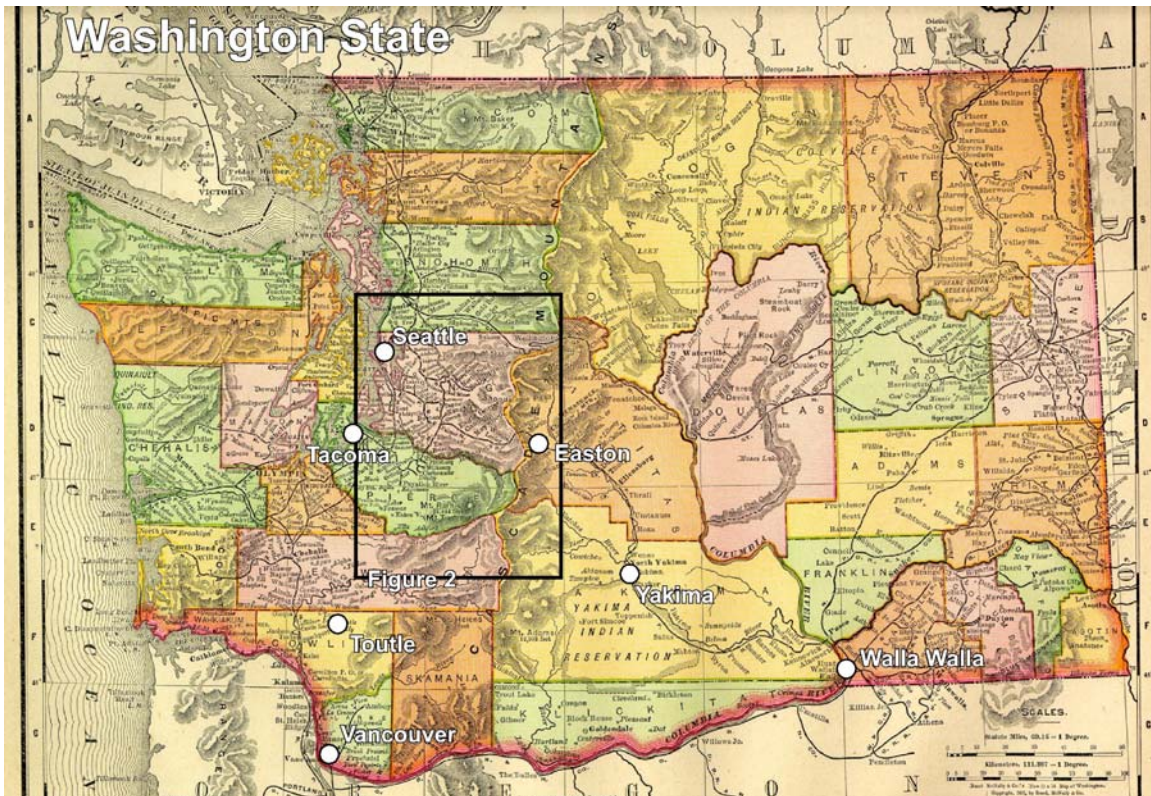
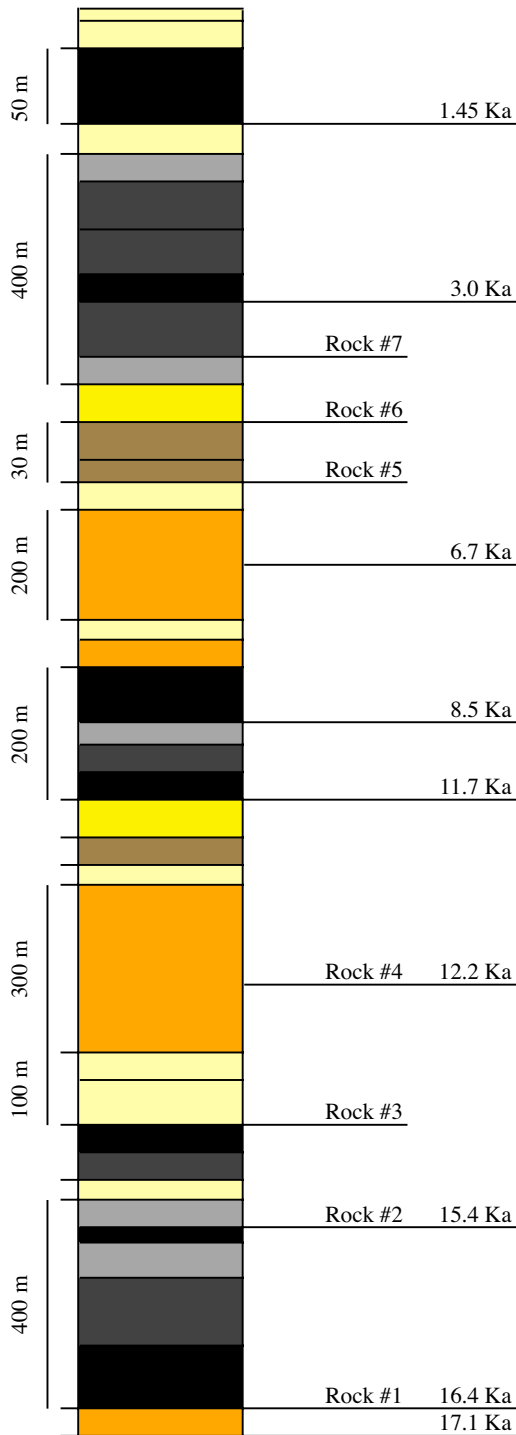


Figure 1: A map ca. 1895 of Washington State. Outline of shaded relief map (Fig. 2) is shown, as well as some major cities mentioned in the problem set.

**Part I: rocks.**

It is important to understand the history of the volcano in order to predict the future. In order to do this, you must know a little something about the distribution of volcanic rocks in the area. Last week, you went out to Washington and collected samples (Fig. 2), made a geologic map and a stratigraphic column for the Mt Rainier eruption history. Since you obviously don't remember doing this, provided in Fig. 3 is the stratigraphic column and the

Fig. 3: Stratigraphy of recent volcanic rocks on Mt. Rainier



This is what we call a stratigraphic column. It is arranged so that the oldest rocks are on the bottom and the youngest on the top, as determined through detailed geologic mapping of the area. Different colors correspond to different rock types. Some approximate thicknesses of units are shown, while the others are relatively comparable. The stratigraphic height of the rocks in the lab are shown; their locations are also shown on the map. Also shown are some ages of the sequence (Ka = thousand years ago), determined by other studies.

stratigraphic locations of the samples you collected (if you don't understand this figure, be sure to ask - it is important). The sample locations are also indicated on the large color map. The rocks in the area are divided into seven rock types, and a representative sample of each is sitting on the table. Write a couple of sentences about each of these rocks – it will help you make sense out of the stratigraphy shown in figure 3 and to therefore understand the eruptive history of Mt Rainier. (10 pts for each question)

1) Rock #1: What is the name of this rock? Is it mafic or silicic? What can this tell you about the potential danger during an eruption of this type? Would you expect to find this rock far from the mountain?

2) Rock #2: Give this rock a name and describe its relation to rock #1.

3) Rock #3: Is this rock mafic or silicic? Name this rock and describe the process that formed it, along with potential hazards it may cause.

4) Rock #4: Describe in several sentences the process responsible for forming this rock. Does this rock represent a potentially dangerous eruption? Why or why not?

5) Rock #5: I will tell you that this is a volcaniclastic rock, but what part of an eruption does this represent (paying attention to where it is found is potentially important)?

6) Rock #6: Give this rock a name. What is the difference between this and rock #1?

7) Rock #7: This rock is very similar to rock #1 but has a higher silica content. What is its name? How would you expect an eruption that spews a lava of this type to differ from that of rock #4?

Synthesis:

8) Describe the eruptive sequence very generally. Is there any cyclicity to the types of eruptions we observe in the geologic record? Of course, we are only concerned with eruptions that have potential to cause significant damage and/or loss of life. What is the approximate recurrence interval of such eruptions on Mt Rainier? Are we due for one soon?

9) What method do you think the scientists used to date the rocks they did? (see problem set #1 for a list of different decay schemes, and their half-lives. Keep in mind that the half-life is not the only important factor, in that you need to have an abundance of the element in a closed-system as well).

## **Part II: the ash**

10) You need to predict where ashfall from an eruption will be concentrated. The best way to do this is to know the weather patterns. Find out the predominant wind direction (by any means you want aside from copying your neighbor), and list the following cities in order of increasing ashfall hazard: Seattle, Vancouver, Yakima, and Walla Walla. See Fig. 1 for the locations of these cities. (10 pts)

11) What potential dangers does ash have, anyways? (10 pts)

## **Part III: the map**

12) It is time to make your volcanic hazard map. The most useful tool you have is the knowledge of how volcanic hazards such as lahars, ashflows and tephra fall behave dynamically. Topography and landscape form have a huge effect on certain types of deposits. What you want to do is draw on your map where the biggest danger is for the following deposits: lahars, ashflows, and ashfall. Develop a color scheme (colored pencils are useful) and fill in where these three dangers are most prevalent. Write a couple sentences for each hazard that explain why you did what you did and show which cities or towns are most in danger from which type of deposit. (50 pts)

## **Part IV: seismology**

This just in: there has been three recent earthquakes which researchers believe may be related to seismicity on Mt Rainier. The first two registered 2.3 and 1.6 on the Richter scale, and their epicenters are located somewhere near the mountain. The third earthquake registered a whopping 4.7 on the Richter scale and the researchers, in a moment of panic, called for the entire state of Washington to be evacuated. You think this is hasty, so you want to check their work. The chart below shows the seismic information needed to find the epicenters for earthquakes #1 and #2, while the actual seismograph readouts for earthquake #3 are given in Fig. 4 (the researchers were so hasty, that they just looked at the magnitude and didn't even process the data).

Station (city)	P-wave arrival time (PST)	S-wave arrival time (PST)
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*Earthquake #1*

Easton	10:23:45.0	10:23:50.5
Seattle	10:23:48.5	10:23:57.8
Toutle	10:23:48.6	10:23:58.0

*Earthquake #2*

Easton	11:03:31.0	11:03:37.7
Tacoma	11:03:31.1	11:03:37.8
Toutle	11:03:33.7	11:03:42.7

*Earthquake #3*

Easton		
Tacoma	<b>See Fig. 4</b>	
Toutle		

13) Plot on your map the locations of the epicenters for all three earthquakes. All the tools you need to do this (other than a ruler and a compass) are in this handout, including P-wave and S-wave velocities in crustal rocks (Fig. 5). (20 pts)

14) Were the researchers justified in thinking that Mt Rainier was about to erupt? Why or why not? (10 pts)

**Part V: the report**

You now need to file a report to the Washington State Natural Hazards Prevention and Safety While Spending the Least Amount of Money Possible Association (WSNHSWSLAMP). Write a 2-page summary of what your assessment above in a format suitable for politicians, including what should be done about the potential hazard associated with Mt Rainier. Assume that your readers have basic geologic knowledge (don't spend space explaining terminology), and do need to be convinced of your argument (i.e. they control your funding). Granted, much of this will be regurgitation of everything you wrote above, and so this should be an exercise in how to concisely and intelligently synthesize as much useful information as possible without losing substance or clarity while presenting a convincing argument. (40 pts)

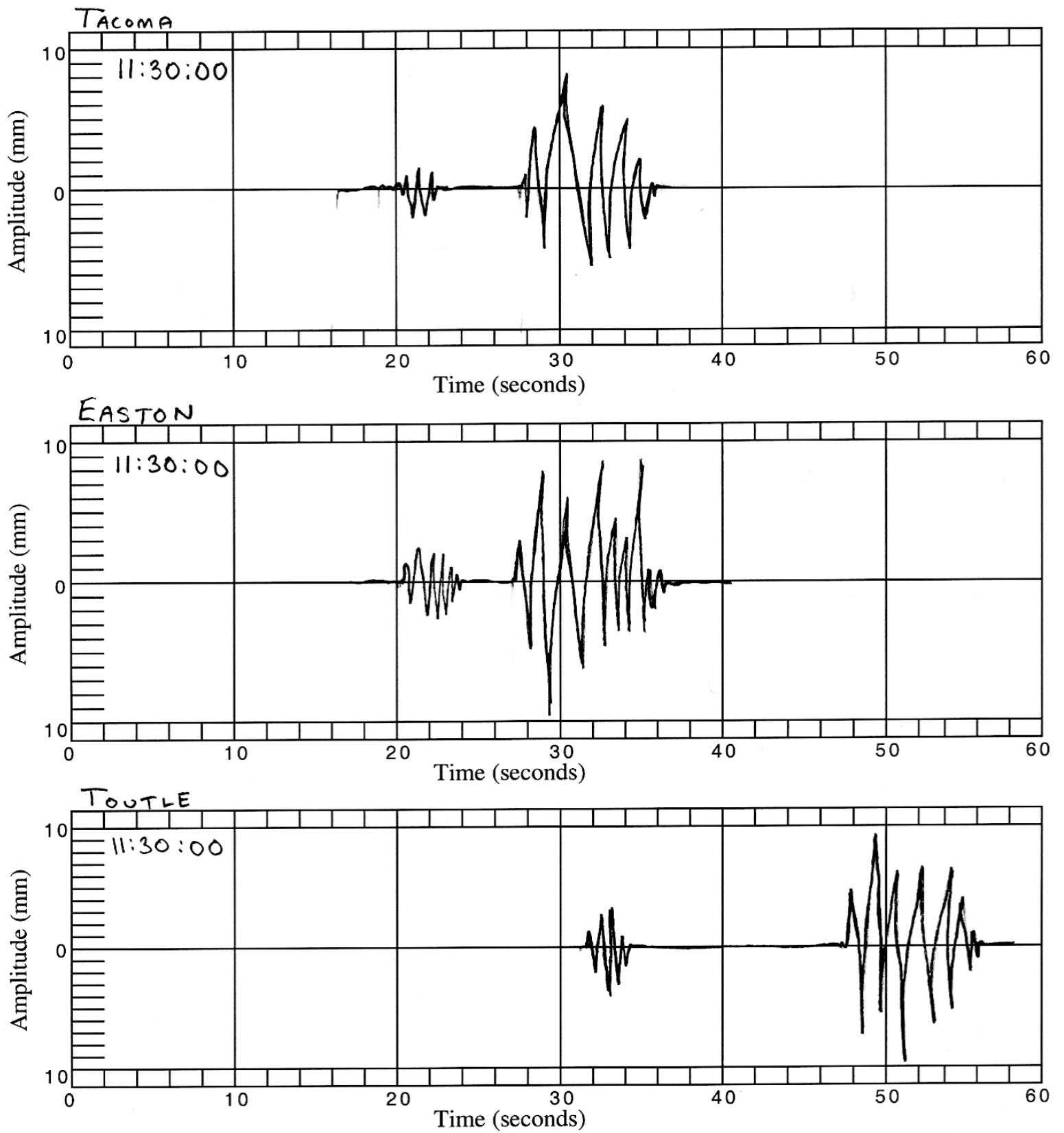


Figure 4: Seismogram for earthquake #3 from 3 stations (see map for locations)

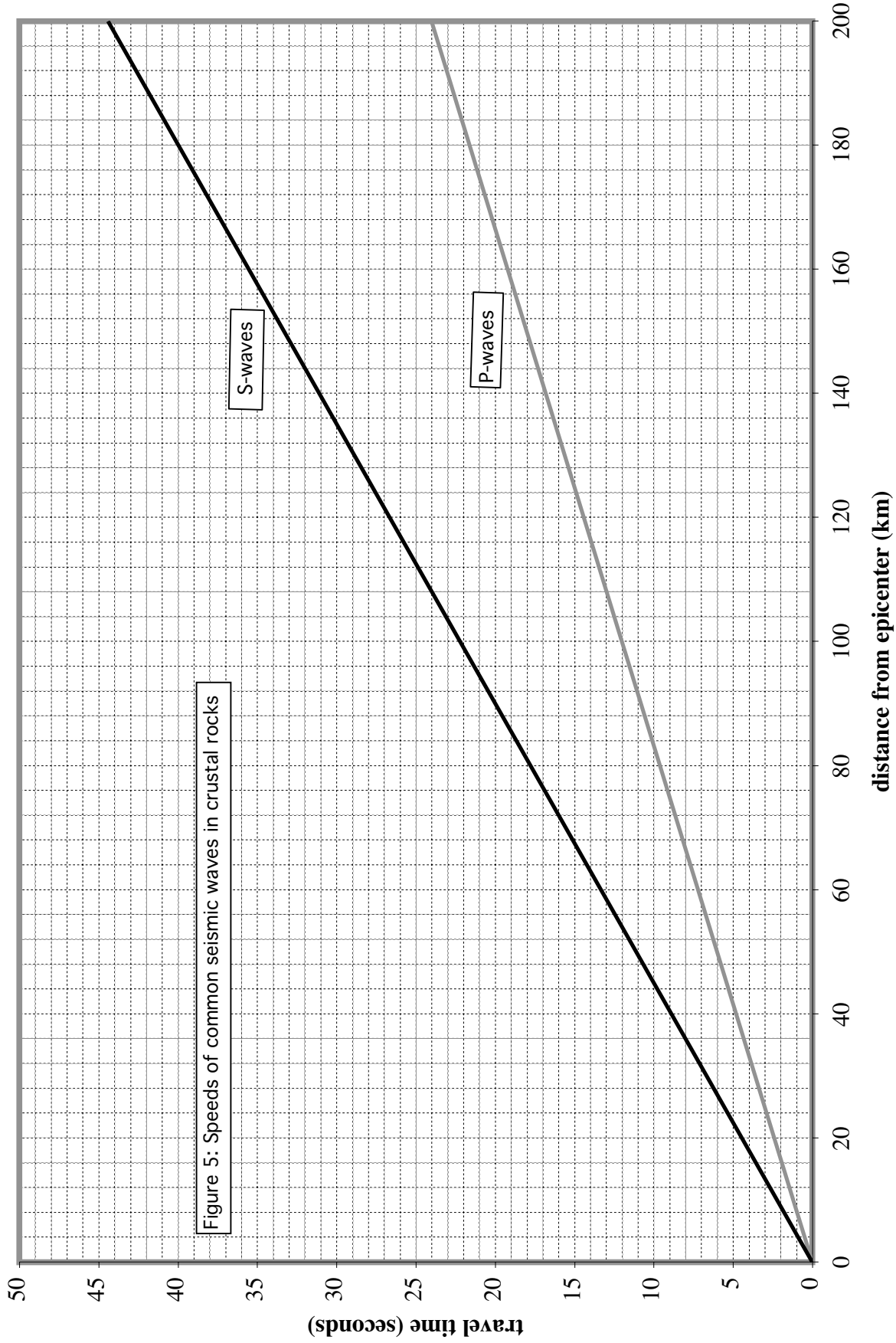


Figure 5: Speeds of common seismic waves in crustal rocks