Earthquake waves: the 'find the earthquake' team challenge

a) Locate an earthquake 'team challenge'

Learning objectives:

- that earthquakes produce **longitudinal primary (P) waves** and **transverse secondary (S) waves**; big **earthquakes** also produce **surface waves**
- the worst surface damage is caused by surface waves, not by the P and S waves
- waves travel at different speeds through the Earth; this can be used to locate an earthquake's **epicentre**
- development of team working skills

Timing: 30 minutes
Health and safety: risks none
Useful web links:
www.earthquakes.bgs.ac.uk (information on recent UK earthquakes)
www.sciencecourseware.com (virtual earthquake exercise)

Activity:

Provide for each team of 3 or 4:

- Read-outs from three stations showing arrival of P and S waves and time differences (Figure 1); these read-outs are from **seismograms** (printouts) produced by the three **seismometers** located at the positions shown in Figure 2.
- A map of the region with scale shown (Figure 2).
- A graph showing the relationship between P and S wave arrival times and distance to monitoring station (Figure 3).
- A complete set of fact cards (below) containing all the information required to solve the problem – and some facts that are superfluous. Fact cards have the following information:
  * what a **P wave** and an **S wave** are (nature and name)
  * what the waves do when an **earthquake** happens
  * that P and S waves travel at different speeds
  * what is the difference in speed
- A pair of compasses.
- 'Helpcards' available with 'clues' if required. These contain more specific directions on how to proceed.

N.B. *Fact Cards are to be copied, cut apart and allocated to team members. Help cards are only to be allocated if required.*
Allocate one or two fact cards per person. Information has to be shared and discussed but, to foster team communication skills, team members are not allowed to show each other their fact cards or to write down elsewhere what is written on each others' fact cards. All members of the team can look at the read outs from the three monitoring stations and the map of the region.
Teams have to devise a strategy to work out the location of the epicentre of the earthquake. The teams compete to be the first to solve the problem and to find the correct location.

Outcome:

Teams work out that the time difference between the wave arrival times depends upon the distance of the monitoring station from the **epicentre**. To locate the

earthquake they draw circles of the appropriate (scaled) radius from the monitoring stations and locate the epicentre where the three circles intersect.

Fact ***P-waves are primary waves because they arrive at monitoring stations first***	***Fact*** ***S-waves are secondary waves because they arrive at monitoring stations second***
Fact ***The time difference between the arrival of P-waves and S-waves depends upon how far the monitoring station is from the earthquake epicentre***	***Fact*** ***P-waves are compression (longitudinal) waves so they travel through the solid parts of the Earth faster than S-waves***
Fact ***S-waves are shear waves so they cannot travel through liquids. They travel about half the speed of P-waves***	***Fact*** ***If a P-wave arrives at a station 1.5 minutes before an S-wave then that station is 900 km away from the earthquake epicentre***

Help card 1: circles drawn with their centres on each monitoring station will intersect at the epicentre of the earthquake
Help card 2: radius of circle is found from the distance of the monitoring station from the epicentre (drawn to scale).

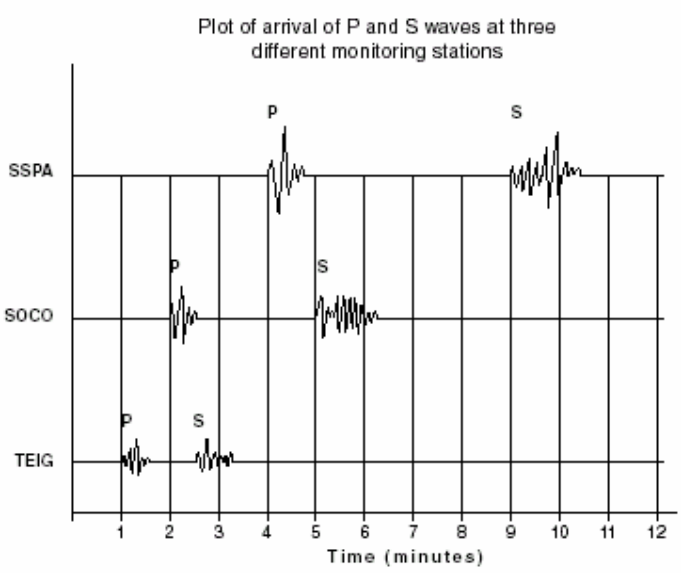
Plot of arrival of P and S waves at three different monitoring stations
P
S
SSPA
P
S
SOCO
P
S
TEIG
1
2
3
4
5
6
7
8
9
10
11
12
Time (minutes)

Figure 1

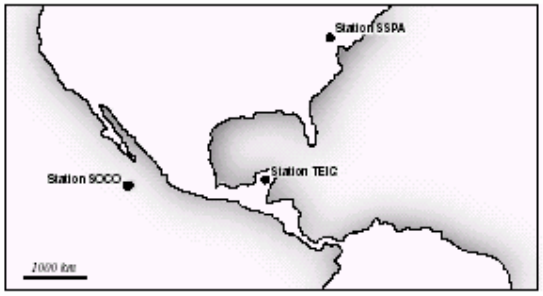

Figure 2

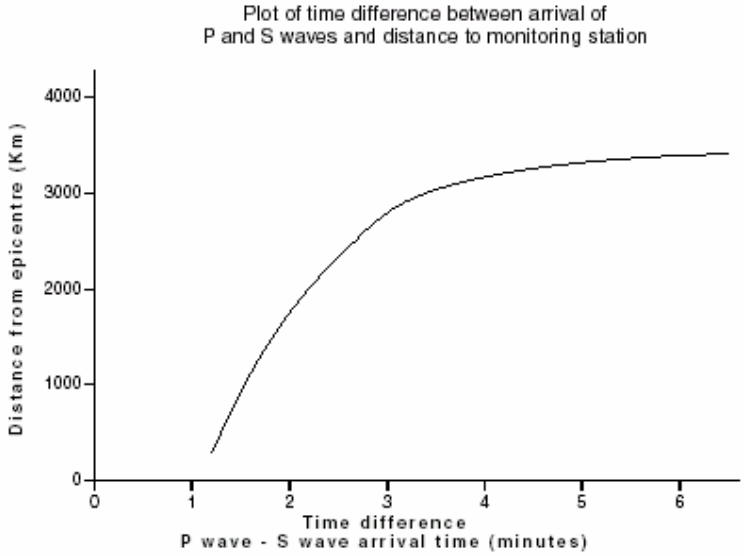
Plot of time difference between arrival of
P and S waves and distance to monitoring station
Distance from epicentre (Km)
4000
3000
2000
1000
0
0
1
2
3
4
5
6
Time difference
P wave - S wave arrival time (minutes)

Figure 3