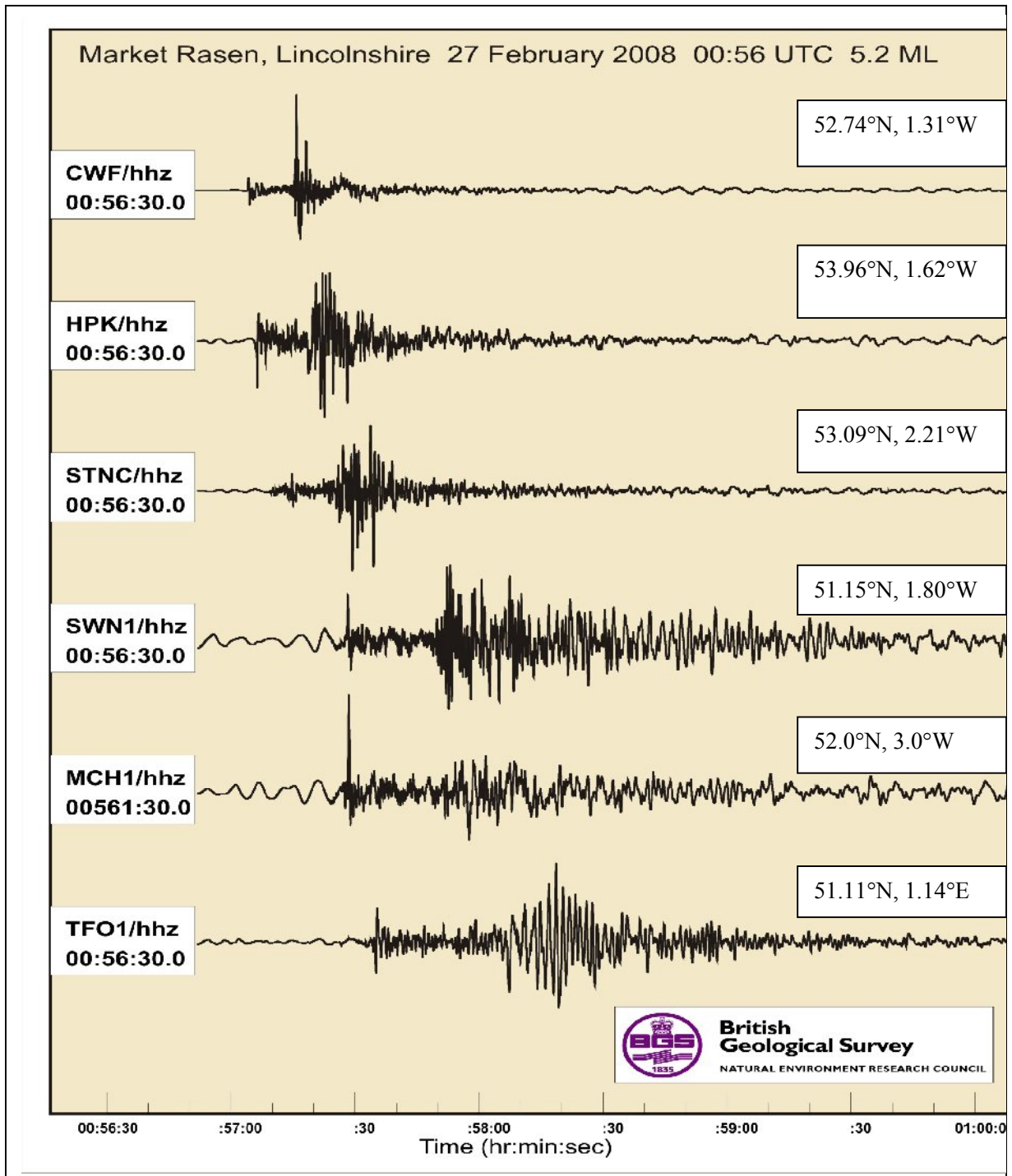
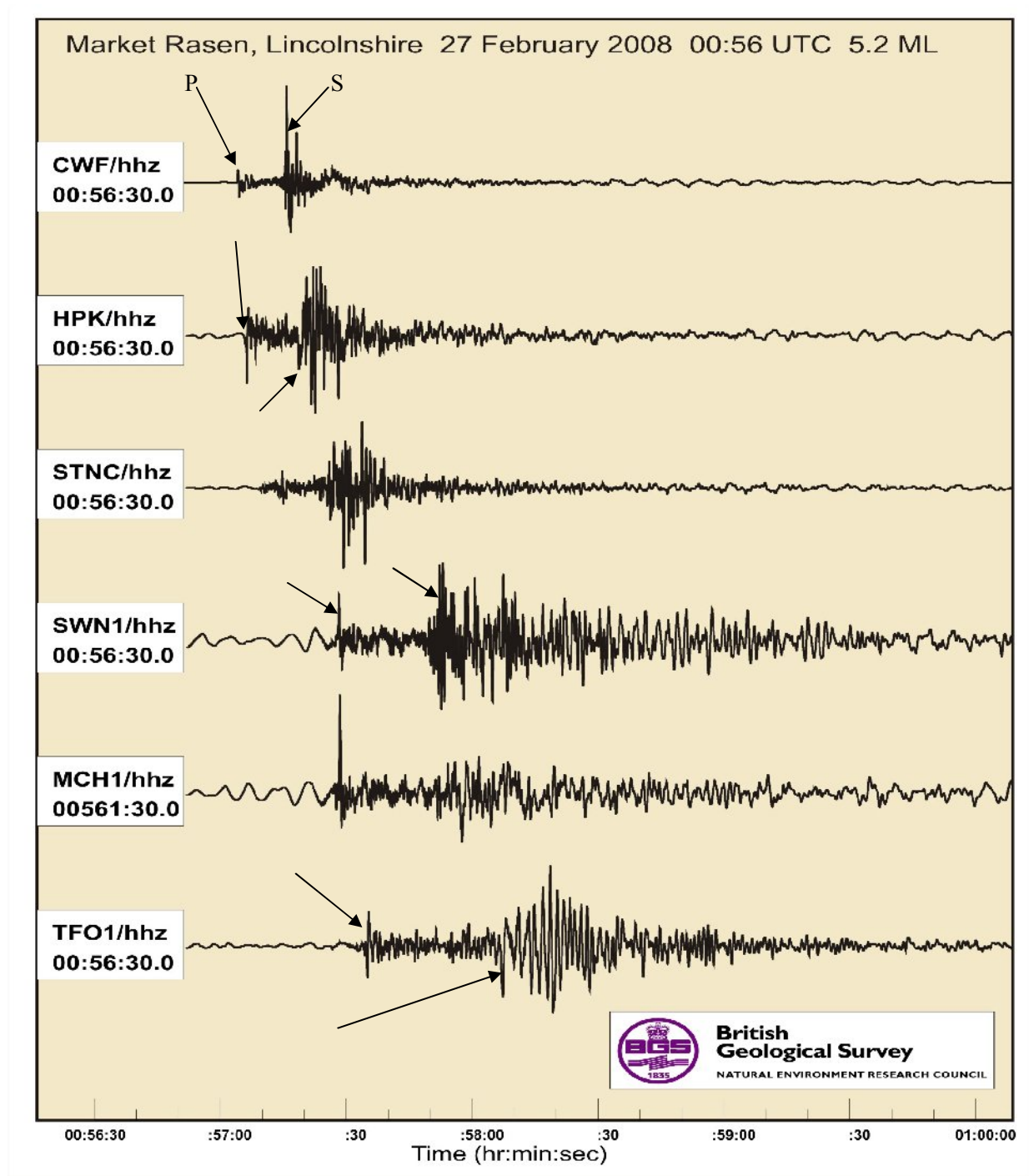


The Market Rasen Earthquake – a nice P3 lesson for a higher tier group.

The following diagram was obtained from the British Geological Survey [BGS] website – the latitude and longitude information was added. When using it with a class, any of the details can be removed.



I have had a go at identifying the P and S waves (see arrows). STNC and MCH1 have no obvious S wave start (at least to me!)

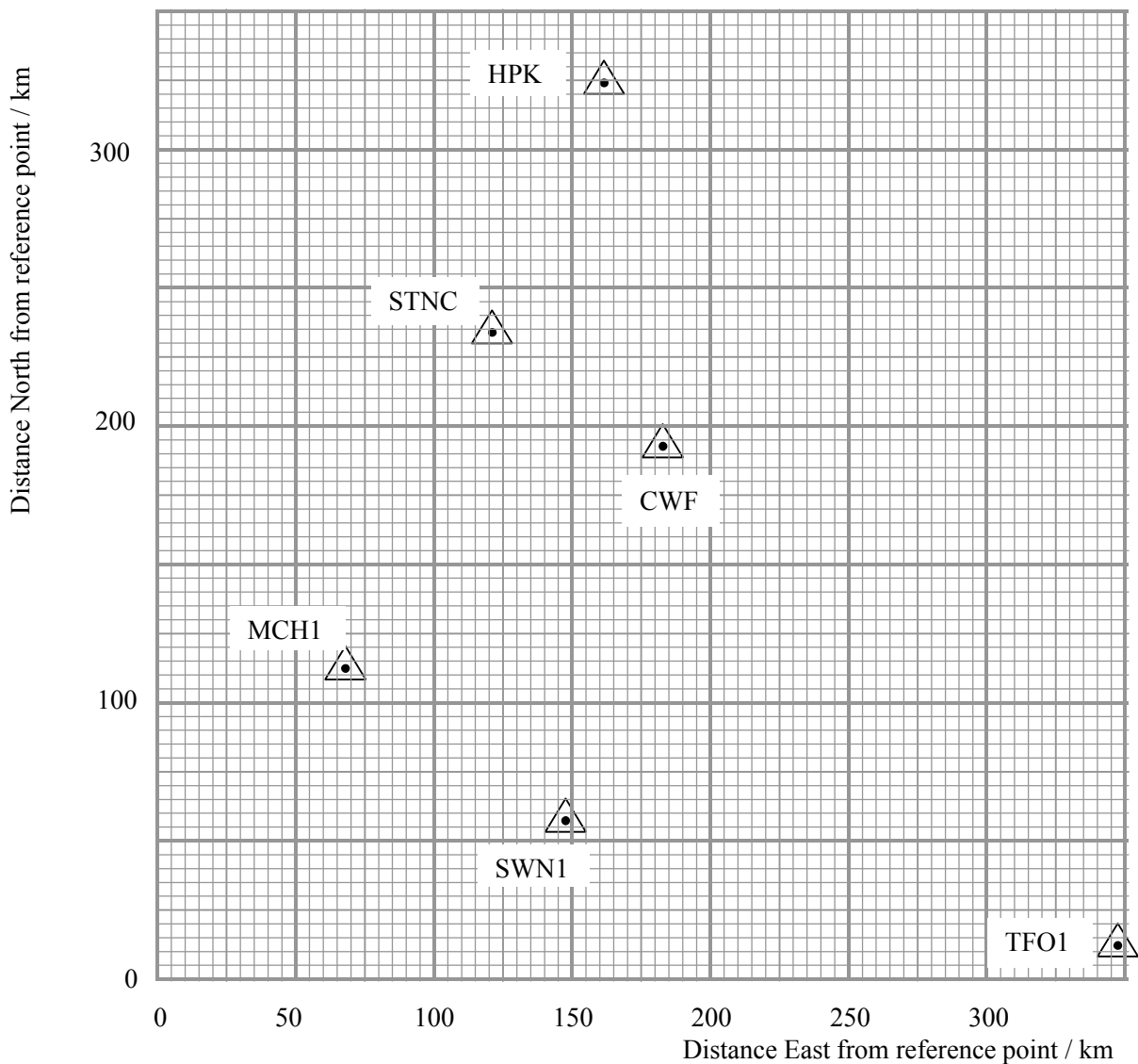


Where are these seismic stations? Look at the diagram below:

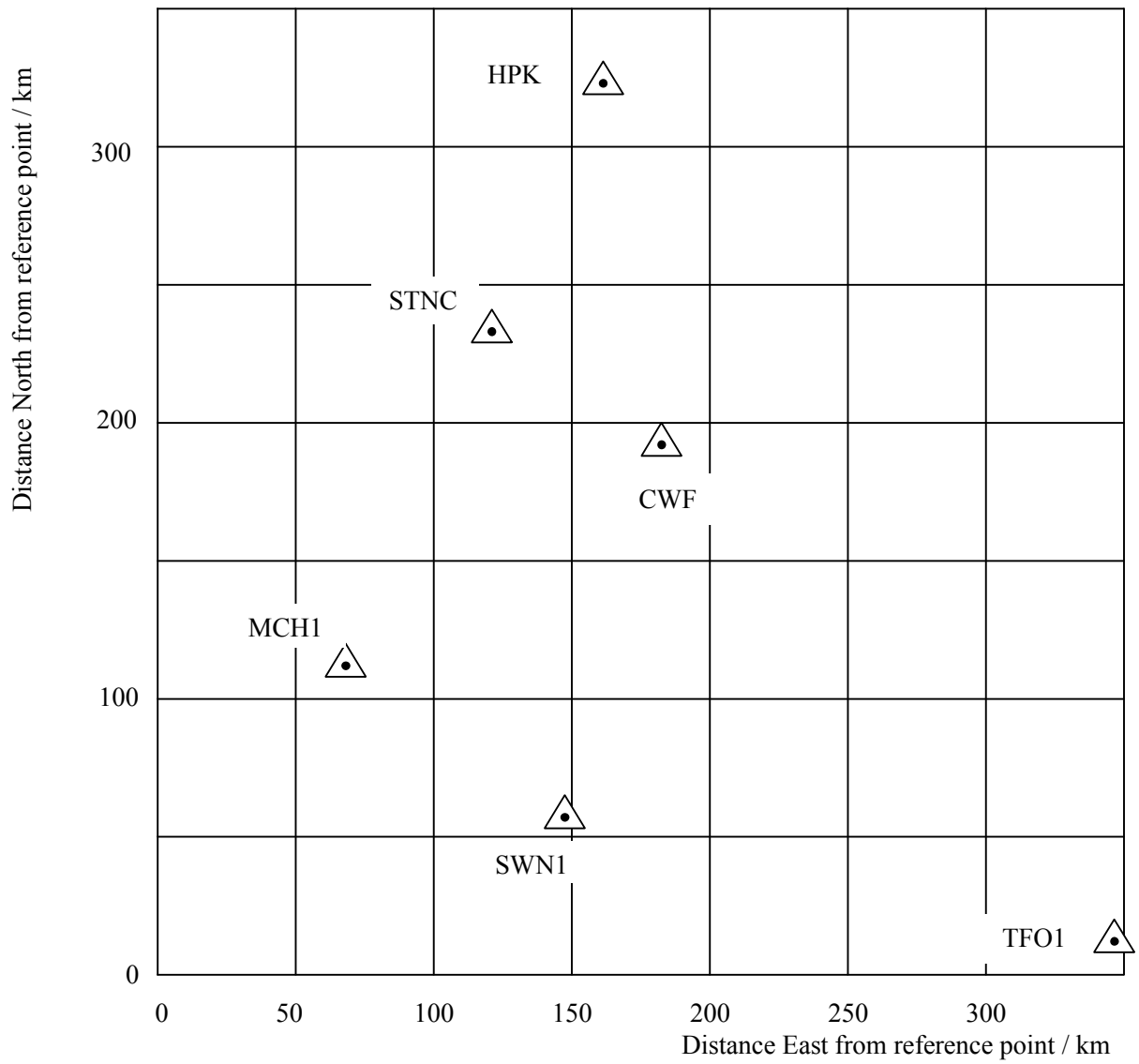
In this diagram, the positions of the seismic stations are plotted using the position 51.0° N and 4.0° W as the origin.

The diagram is an approximation because the surface of the Earth is curved and the diagram is flat. The North co-ordinates are determined using the conversion factor $1^\circ \approx 111.2$ km. The East co-ordinates use the conversion factor $1^\circ \approx 67.8$ km, which is correct for a latitude of 52.7° N, which is roughly the centre of the diagram.

The scale is 4 cm \approx 100 km.



Alternative diagram – the scale is the same.



How to use the seismograms to estimate the position of the epicentre:

The basic idea is that of the **P-S lag time**. This is the time delay between the arrival of the P waves and the S waves. These waves are sent out as a result of a geological fault suddenly slipping. Both types of wave are produced at the same time but the P waves travel more quickly and so reach distant seismic stations first.

To a reasonable approximation, the P waves in the crust travel at about 8 km/s and the S waves at about 4 km/s. From these figures, it can be shown that, if the seismic station is a distance d away:
 $d \sim 8 \times \Delta t$, where Δt is the lag time.

So:

1. Identify the start of the P and S waves – this is not clear with STNC [Keele] and MCH1 [Michelhurst]. Suggested positions are shown by arrows.
2. For each seismograph, use the time scale to estimate the time delay between the arrival of the P and S waves – the lag time, Δt .
3. Use the approximation that each second of lag time represents 8 km, to estimate the distance from the epicentre.
4. Use a pair of compasses to draw a circle of the correct radius, centred on HPK, to show the possible positions of the epicentre.
5. Repeat this for CWF. Identify the 2 possible positions for the epicentre.
6. Repeat this for TFO1. What can you say about the position of the epicentre? Does it agree with the information from SWN1?

Derivation of the lag-time / distance formula:

Let d = distance to focus, v_p = P wave speed, v_s = S wave speed, Δt = lag time.

Time for P waves to arrive = $\frac{d}{v_p}$. Similarly: Time for S waves to arrive = $\frac{d}{v_s}$.

$$\therefore \Delta t = \frac{d}{v_s} - \frac{d}{v_p} = d \left(\frac{1}{v_s} - \frac{1}{v_p} \right).$$

$$\therefore d = \frac{\Delta t}{\left(\frac{1}{v_s} - \frac{1}{v_p} \right)}. \text{ Using units of s, km and km/ this becomes: } d = \frac{\Delta t}{\left(\frac{1}{4} - \frac{1}{8} \right)} = \frac{\Delta t}{\frac{1}{8}} = 8\Delta t$$