This lesson teaches students about earthquake location using triangulation of arrival times of seismic waves, allowing them to practice graph skills and application of speed/distance/time equations. An example is shown from an explosion source in North Korea. This can be used to open a discussion about the uses of seismology in terms of monitoring the nuclear test ban treaty. It also leads into a discussion of the wide range jobs within geosciences beyond looking at rocks and dinosaurs. An accompanying powerpoint presentation, recap quiz for the previous lesson, pupil worksheet (and answers), seismograms and map related to the location activity are included in the lesson 2 resource pack.

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| **Cycle** | **Aims** | **Teacher instructions** | **Pupil focus** | **Timing/ mins** |
| Starter/ recap | - Thinking about a drum seismometer  - Quiz to check basic knowledge from the last lesson (waves, seismic waves)  - Quick refresh of key points from the last lesson | Show the video on the starter slide. Students talk briefly to the person next to them. Show the next slide which has an explanation. Next move on to the recap quiz. It is very simple, so if you think you do not need it you can cut this part or use another way of checking that the students remember the previous lesson. Alternatively, you can add additional questions to the quiz as you see fit. Then there are a couple of slides which recap the previous lesson. | Thinking about how a seismometer works, recapping the content from last lesson | 10 |
| Main activity: Triangulation of an explosion | - Practising graph skills  - Applying knowledge to solve a problem  - Understanding how this application of science works | This exercise can be done in pairs. The students will read (for each station) a seismogram (recording of ground motion showing arrival of seismic waves) to find the time of the first P wave arrival and the time of the first S wave arrival. They will read off a separate graph to find the distance of the explosion from the station using the difference in P and S wave arrival time. Then, they will draw a circle with that distance as its radius on the map. They should measure the scale bar on the map and decide how to convert their value to be drawn on. They repeat this process for the next station. Different pairs should start with different stations so that at the end of a set time they can feed back, and all the stations have been done. Results can then be shared, and students can add the rest of the circles to their maps. All the circles should approximately intersect at one point (North Korea) as shown in the answers – this is where the explosion happened (this relates to a real explosion connected to recent North Korean nuclear tests). BE AWARE: these are not real seismograms from this event - explosions sources show more complex waveforms with larger P wave arrivals due large amounts of compressional energy and smaller amounts of shear energy released in explosions compared to Earthquakes.  Each student gets a worksheet and each pair gets a map, a graph, and a set of seismograms. Each pair needs a compass for drawing on the map. Students can follow the instructions on the worksheet. You may need to initially check they can read the seismograms correctly. The first small wave arrival is the P wave arrival, then the second noticeably larger amplitude wave arrival is the S wave arrival. You can check that you get the same values as the answer sheet when you read them. You look for the beginning of each wave packet and read the time on the x-axis. Two examples are shown below. | Reading off seismograms, using a graph to find the distance from each station, drawing this on to the map to triangulate the position | 30 |
| Quick activity: Calculating depth of an earthquake | - Practising applying an equation to solve a problem | Students are shown the slide showing pP waves. These are waves that travel upwards and bounce of the surface of the Earth before travelling down through the Earth’s mantle, unlike the direct P waves which travel straight to the seismometer. Students are given information that will allow them to work out the depth of the Earthquake using simple speed/distance/time relationships based on the arrival time of pP waves compared to direct P waves. Some prompting may be needed  You can put up the slide which shows the question, get them to work it out. Then put up and discuss  answers. | Problem solving | 5 |
| Contextualising | - Slide on real seismologists, and slides on geoscientists | Final slides that put their learning into a modern global context, discussing how and why the international seismic network came about in response for the need to monitor the nuclear test-ban treaty and showing the range of exciting jobs in the geosciences. Get pupils to discuss what people in the pictures are doing and what type of jobs might do.  Examples include:  Seismologists - studying earthquakes or using them to study the structure of the Earth  Geophysicists - studying the physics of the Earth (magnetic field/gravity/seismology)  Volcanologists - studying volcanoes  Geotechnical engineers - checking sites for structural stability relevant to building infrastructure  Geochemists - study the chemistry of rocks/water/ice links to understanding past climate variations  Palaeontologists - study fossils and ancient lifeforms  Geologists - study rocks  Glaciologists - Study glaciers  Geodesists - studying deformation of the Earth’s surface using satellite data  Planetary scientists - apply concepts to other planets | Understanding the recent history importance of seismology and the variety of opportunities available in geosciences | 5 |



