EARTHQUAKES in Britain?

Science content

Earthquakes, Richter scale, Mercalli scale, seismograph, seismogram, speed, time, vibration.

Science curriculum links
AT 1 Exploration of science
AT 9 Earth and atmosphere

Syllabus links
- GCSE Science
- Geography

Cross-curricular themes
- Environment

Lesson time
1–2 hours
and homework

Links with other SATIS materials
1107 The Eruption of Mount St Helens

NERIS
Search on
EARTHQUAKES and UPPER SECONDARY

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SUMMARY

Part A is based around an earthquake that occurred in North Wales in July 1984. It describes the experiences of people who felt it and relates them to the Mercalli scale. Students may then determine the location and time of the earthquake. Part B deals with seismographs and part C is an earthquake hazard survey of the home.

STUDENT ACTIVITIES

- ☐ Introductory reading: Richter and Mercalli scales
- ☐ Questions relating observations to the Mercalli scale
- ☐ Plotting an isoseismal map
- ☐ Interpreting seismograms
- ☐ Making an earthquake detector
- ☐ Questions for group discussion – civil emergencies
- ☐ Home survey – preparedness for an earthquake emergency

AIMS

- ☐ To link with work on plate tectonics and earthquakes
- ☐ To consider the precautions that individuals can take to prepare for a natural disaster
- ☐ To provide opportunities for assessing evidence and interpreting seismic data
- ☐ To provide an opportunity to design, make and evaluate a seismograph

USING AND ADAPTING THE UNIT

- ☐ Part A is suitable for independent work or for homework. 'When did the earthquake occur?' might be omitted by students who find the mathematics too challenging.
- ☐ Worksheets are provided for use with parts A and C.
- ☐ The apparatus for part B, 'Can you make an earthquake detector?' should include a variety of items such as: hacksaw blades, G cramps, masses, springs (as used for Hooke's Law experiments), pendulums, retort stands, wooden blocks, thread, card, paper, Sellotape, plasticine, fibre-tipped pens.

Teaching notes

The unit is divided into parts so that teachers may select those most appropriate to their class.

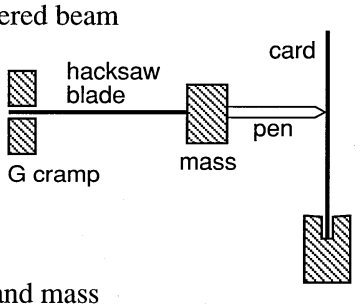
There is no direct correlation between the Mercalli and Richter scales. Values for earthquake intensity on the Mercalli scale are a little higher than on the Richter scale. The Richter scale is logarithmic – like the decibel scale for the intensity of sound.

Part B 'Can you make an earthquake detector?'

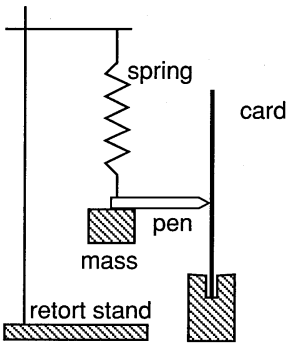
A seismograph has a part that moves with the Earth's vibration and a part that stays still.

- It is suggested that students are told what apparatus is available and that they may select what they need.
- A suitable time limit is 30 minutes.
- Typical student designs are

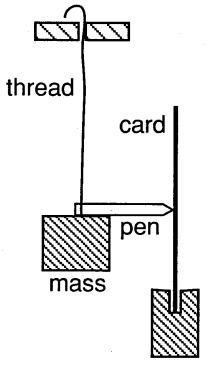
(i) cantilevered beam



(ii) spring and mass



(iii) pendulum



After students have completed their seismographs, it is important that the class reviews their designs to evaluate:

- whether their devices measure horizontal or vertical vibrations,
- their sensitivity to vibrations,
- the reliability of their detectors,
- the validity of their measurements,
- the connection between the external vibration (the independent variable) and the device's response (the dependent variable), the device's response being a trade-off between springiness and inertia.

Acknowledgements

Dennis Curry of University College, London, read and commented on the trial version.

The material on the 1984 North Wales earthquake has been developed from an article by Peter Whitehead which appeared in *Geology Teaching*. The data was supplied by the Department of Earth Sciences at Leeds University.

Figure 2 is reproduced by permission of the *Shropshire Star*.

Figures 3 and 7 by Joyce Curtis.

Answers to the questions

Q1 *Between 3 and 4 on the Mercalli scale.*

Q2 *(a) Hanging objects swing – lamp over bunk, picture on wall, plant on wardrobe would shake, curtains swing; the vibration will be more noticeable in the upper bunk. Cat will wake up.*

(b) Vase and books may fall off the shelf, so will items on the chest of drawers, bedside table, plant on wardrobe, picture and mirror on the wall: standard lamp may fall over: bunk beds shake; weak plaster in walls may crack and so may the window glass.

(c) The wardrobe and bunk beds might topple over, other furniture would move, books and ornaments would be thrown to floor. There would be damage to the plaster on the walls.

Q3 *4*

Q4 *Possibly little higher.*

Q5 *Caernarfon and Pwllheli*

Q6 *Oxenhope*

Q7 *1.8 s approximately*

Q8 *5.5 km/s*

Q9 *210 km*

Q10 *38 s*

Q11 *(a) 6:56:43, (b) 6:56:41*

Q12 *6:56:03*

Questions for group discussion

- *(a) radio – in the probable event of power being cut off, to receive information, for example on location of emergency medical centres, roads closed, arrangements for water supplies etc.;*

  (b) water purification tablets – water mains are often fractured by earthquakes; water supplies may become contaminated giving rise to outbreaks of disease;

  (c) heavy gloves – for lifting rubble to rescue people trapped underneath;

  (d) map – used to the help find routes to emergency centres should the usual routes be blocked.

- *Scores will depend on individual preferences.*

- *(a) Floods, damage by gales, inundation by the sea in coastal areas, forest fires, etc. (b) The items on the list are useful for any civil emergency.*

EARTHQUAKES in Britain?

Part A – Do earthquakes occur in Britain?

What does an earthquake feel like? Here are descriptions by two schoolchildren of an earthquake that happened in Britain in 1984.

'I was sitting on the toilet and thought the seat was moving.'

'My Mum told me to stop jumping on my bed and I said it wasn't me.'

Occasionally there are earthquakes whose effects are more serious. In 1580 an earthquake centred around the Straits of Dover destroyed buildings and set the church bells ringing all over Kent. In 1884 a church in Colchester, Essex, was wrecked and more than a thousand buildings damaged. An earthquake in 1990 damaged buildings in Shropshire.

When an earthquake occurs a lot of energy is released and the ground shakes. Two scales are used for measuring earthquakes: the Richter scale and the Mercalli scale.

The **Richter scale** is related to the amount of energy released. It is used when the earthquake has been detected by **seismographs**.

The **Mercalli scale** is used to estimate the size of earthquakes which have not been recorded by seismographs. This scale is based on what people notice when the earthquake occurs and by the damage it does. There is a simplified version on the next page. The two scales are compared below.

Part A Earthquake intensity, relating observations to the Mercalli scale, plotting an isoseismal map, interpreting seismograms. (Students will need worksheets 1 and 2.)

Part B Seismographs; build an earthquake detector.

Part C Discussion questions; survey of earthquake hazards in the home. (Students will need worksheet 3.)

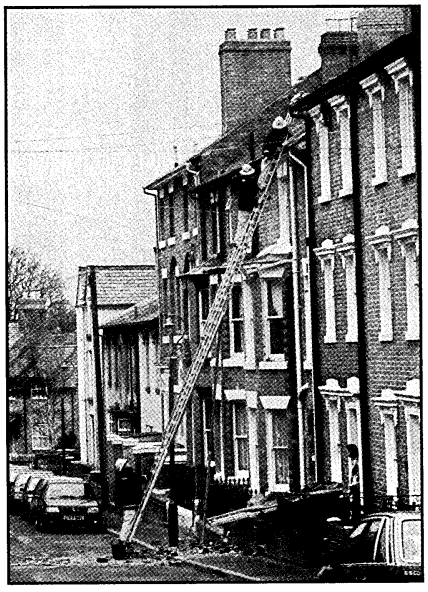
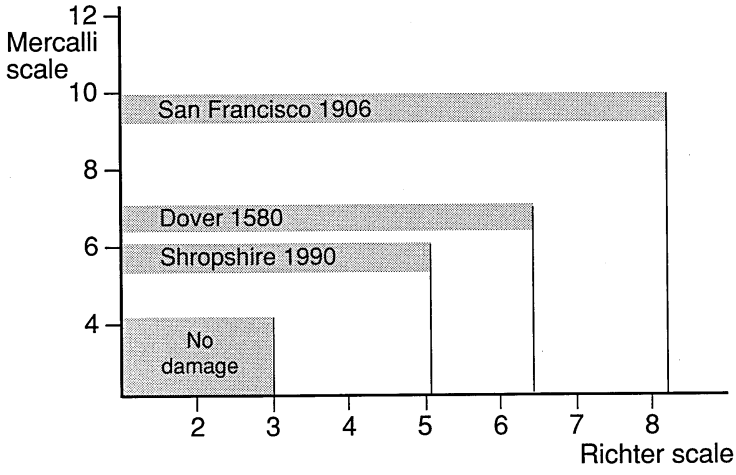


Figure 2 Firemen making safe a chimney stack in Shrewsbury after an earthquake in Shropshire in 1990. Its magnitude was put at 5.1 on the Richter scale

Figure 1 A comparison of the Richter and Mercalli scales



The Mercalli scale

1 People don't feel it. The shock is recorded by seismographs only. Some animals feel uneasy. Delicately hung objects swing.

2 Only people at rest indoors feel it, especially upstairs in buildings.

3 It seems like the vibrations of a passing lorry. Many people do not recognise it as an earthquake. Hanging objects swing.

4 Many people indoors can feel it and a few people out of doors. It may awaken some people at night. Walls make a creaking noise. The sensation is like a heavy lorry hitting the building. Standing cars rock noticeably.

5 Nearly everyone feels it. Some dishes and windows are broken, doors swing, some plaster cracks.

6 Everybody feels it. Many people are frightened and run outdoors. Books and ornaments fall off shelves. Trees and bushes shake. Small church bells ring, some plaster falls down and chimneys are damaged.

7 It is difficult to stand up. People in vehicles notice it. Furniture breaks, weak chimneys break at the roof line. You can see waves on ponds and pond water becomes clouded with mud from the bottom.

8 Buildings start to collapse. It is difficult to steer a car.

9 General panic; ground cracks, buildings shift off foundations, reservoirs damaged.

10 Landslides, most brick buildings destroyed. Wooden buildings damaged.

11 Few buildings left standing. Bridges destroyed, underground pipes broken.

12 Damage total: waves on the ground; objects thrown up into the air.

Earthquake 1984

The earthquake which occurred in Britain in 1984 happened at about eight o'clock in the morning.

A questionnaire about the earthquake was sent to schools in the Walsall area. Of the 350 people who replied, 212 had felt nothing because they had been asleep or on a bus at the time. One hundred and thirty-eight people reported feeling the quake. Of these, 50 people reported that animals had behaved strangely, either before or during the quake.

Earthquake 1984: what did people in Walsall notice?

'A lot of birds were flying around – don't usually see them.'

'Most of the dogs were barking.'

'Dog ran under the bed the night before and would not come out – this was most unusual.'

'I was asleep and heard a bang. It woke me up.'

'The bed shook, doors closed and rattled.'

'The room began to move as if someone was hitting the walls with a large hammer, accompanied by a rumbling sound.'

'It was like a lorry passing, hardly noticeable.'

'The bed began to shake and the jars in my bedroom shook and clanked together.'

'I was in bed and the bed shook. I thought I was going dizzy so I sat up and it carried on for two more seconds. I went downstairs and no-one said anything about it so I thought I had imagined it.'

'It was like a lorry driving at high speed directly outside the house.'

'There were two tremors, each lasting about eleven seconds with the same effects.'

'Cupboards and wardrobes shook. Outside the TV aerials swayed.'

The effects of the earthquake in other parts of the country varied. Near the **epicentre** – where the earthquake occurred – some buildings were slightly damaged.

Earthquakes usually last for a minute or so. They are caused by a sudden release of energy in the Earth's crust or upper mantle producing seismic waves.

A **seismograph** is an instrument that detects and records earthquakes.

The **epicentre** is the place on the surface of the Earth directly above the **focus** of an earthquake. Earthquakes which occur less than 70 km under the surface of the Earth are the most destructive to buildings. These are known are 'shallow-focus' earthquakes.

Q1 *Read the comments of people in the Walsall area. What number on the Mercalli scale would you give to the effects of this earthquake in Walsall?*

Q2 *Suppose you were sleeping in the bedroom in figure 3. Describe what might happen during an earthquake of strengths: (a) 3, (b) 5 and (c) 7 on the Mercalli scale.*

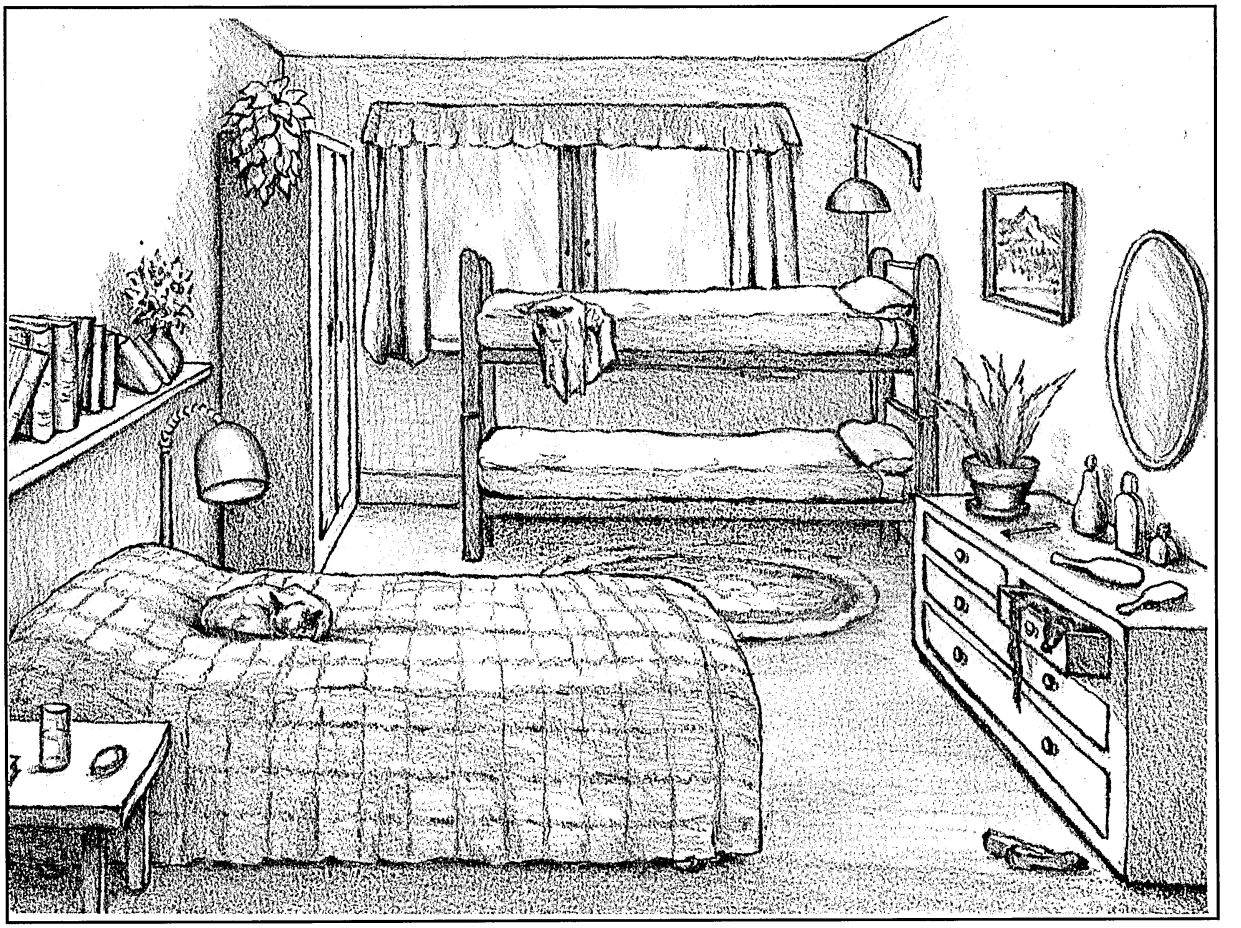


Figure 3 Would you be safe in this room during an earthquake? See question Q2

Where did the earthquake occur?

The intensity of the 1984 earthquake in different parts of Britain is given in table 1.

Table 1 The intensity (Mercalli scale) of the 1984 earthquake in towns and cities across Britain

Town	Intensity
Glasgow	3
Newcastle	3
Belfast	4
Londonderry	3
Lancaster	4
Leeds	4
Grimsby	3
Holyhead	5
Caernarfon	6
Waterford	4
Cork	3
Pwllheli	6
Coventry	4
Cambridge	3
Barmouth	5
Cardiff	4
London	3
Plymouth	3
Southampton	3

Activity *(Use worksheet 1)*

1 Worksheet 1 is a copy of the map of Britain, shown in figure 4. Write the intensity values from table 1 beside the dot marking each town on the map. For example, put a '3' beside Glasgow on the map.

2 Join all the dots that have the same value. Make smooth curves. (These curves should not cross each other.)

This is an **isoseismal map** of the earthquake.

Q3 *What according to the isoseismal map, was the intensity of the earthquake in Walsall?*

Q4 *How does this value compare with the evidence provided by the Walsall school survey?*

Q5 *Which two towns on the map appear to lie closest to the epicentre?*

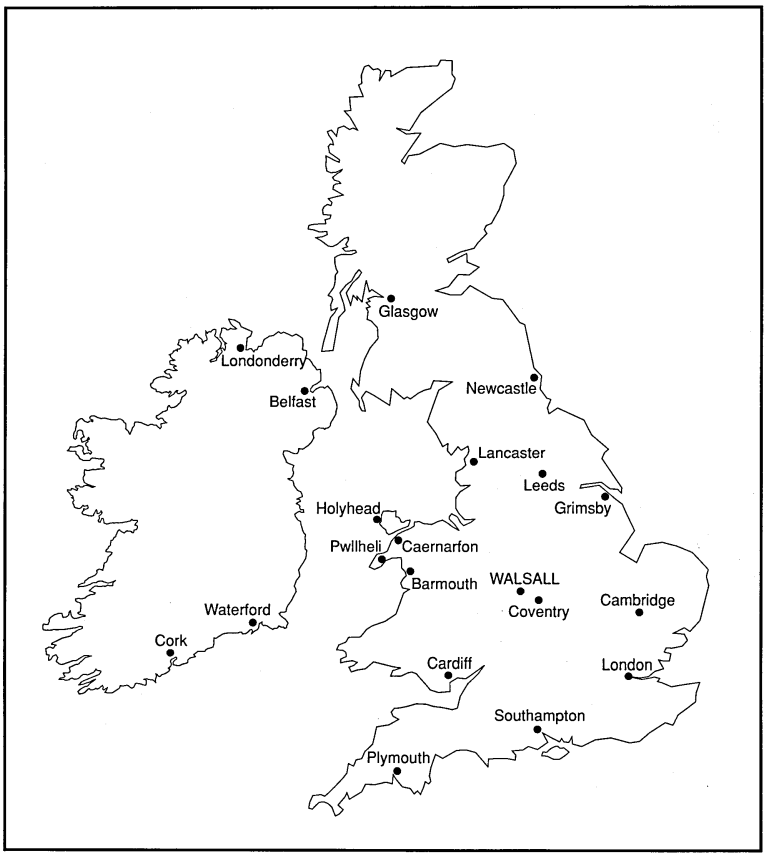


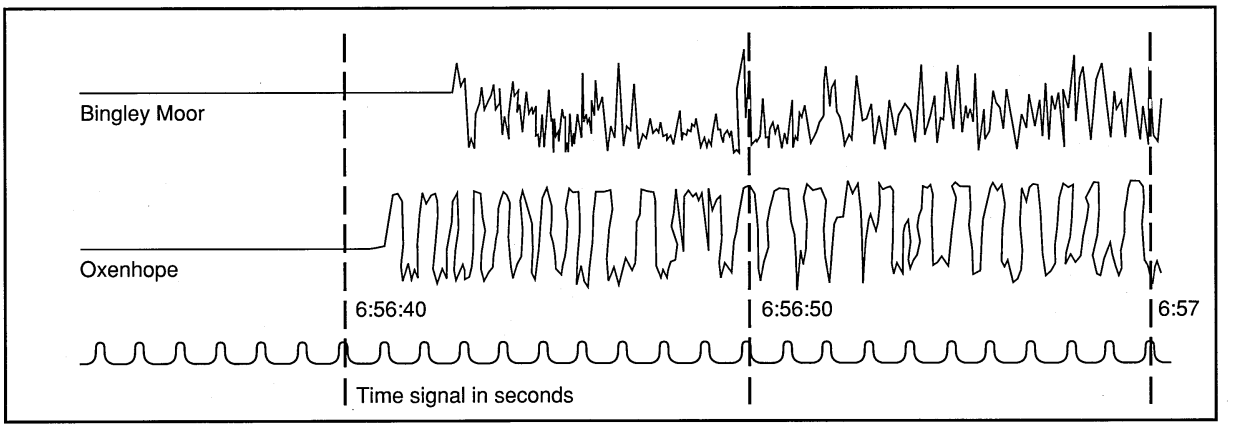
Figure 4 Map of the British Isles showing the position of the towns and cities in table 1. Use the copy of this map on worksheet 1.

When did the earthquake occur?

The traces in figure 5 show shock waves from the 1984 earthquake arriving at seismographs at Bingley Moor and Oxenhope. These earthquake monitoring stations are situated near Leeds and are 10 km apart. By chance, they were exactly in line with the epicentre of the earthquake. The third trace shows the time in seconds and reads in Greenwich Mean Time.

The traces were made just before 7:00:00 GMT (in other words, just before 8.00 a.m. British Summer Time).

Figure 5 Seismograms of the 1984 earthquake as shown on worksheet 2



Work from the map and traces on worksheet 2. Assume the earthquake occurred at the surface.

Q6 *Which station did the shock wave reach first?*

Q7 *Use the timescale on worksheet 2 to find the time-lag between the first arrival of the shock wave at the two stations.*

Q8 *The recording stations are 10 km apart. How fast was the wave travelling?*

Q9 *Mark on the map the position of the epicentre of the earthquake. Use the scale of the map to estimate how far it was from Oxenhope.*

Q10 *How long would the wave take to travel this distance?*

Q11 *At what time (to the nearest second) did the first arrival occur at (a) Bingley Moor, (b) Oxenhope?*

Q12 *At what time GMT did the earthquake begin?*

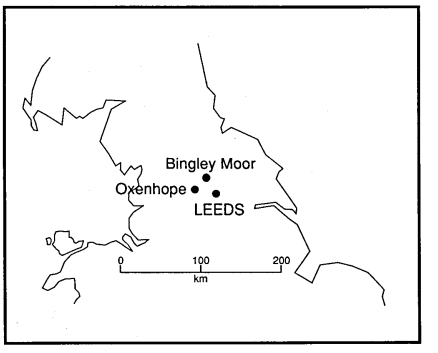


Figure 6 The location of the earthquake monitoring stations, Bingley Moor and Oxenhope

Part B – Detecting earthquakes

When an earthquake occurs, its strength and position are calculated using readings from many seismographs.

Figure 7 A Chinese earthquake detector invented in 132 AD

The Chinese invented the first earthquake detectors. They looked like large pots. When an earthquake occurred, dragons near the top of the pots spat balls into the mouths of the frogs below. Information about which balls had fallen from several detectors told them where the earthquake had happened.

Geologists now use seismographs to measure either vertical or horizontal movements of the ground. The motion is magnified electronically and a trace recorded on a rotating drum. Modern seismographs are so sensitive they can measure ground movements as small as 0.000 000 000 1 m.

The problem in measuring vibrations is to have a steady point when the ground moves. In figure 8, this is the pen. It remains steady when the ground moves because it is attached to a large mass. (A large mass has a property called inertia – it does not like to change its position.)

Can you make an earthquake detector?

Using the apparatus available to you design, build and test an earthquake detector. It should detect and record the vibrations caused by someone hitting the bench on which it stands.

A good device should have a measuring scale somewhere to show the difference between a light and heavy bang.

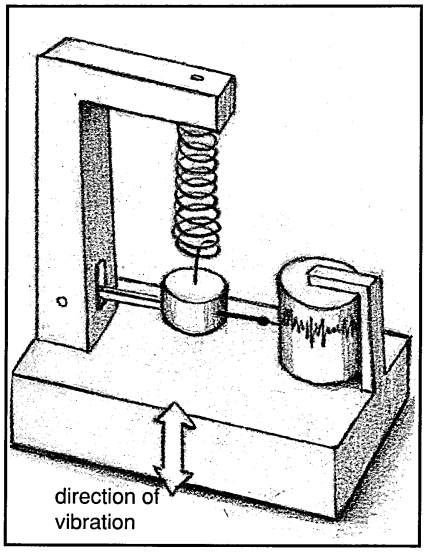


Figure 8 A simple seismograph

1 *Draw a diagram to show how your apparatus worked.*

2 *Explain how it detected the bang – which bits moved and which did not.*

3 *Was the apparatus reliable? Say if it worked every time.*

4 *Suggest how it could be improved.*

5 *Did it detect the difference between a light and a heavy bang?*

6 *Were you able to calibrate it?*

Part C – A big British quake?

Most earthquakes happen where two of the Earth's tectonic plates rub together.

Earthquakes can also occur within plates due to the release of stresses locked up in ancient faults. Although Britain is far from any plate margin, there have been several earthquakes with an intensity of 6 on the Mercalli scale (about 5 on the Richter scale) in the last hundred years. Geologists believe that even stronger earthquakes could occur at any time.

In Japan and California, USA, where strong earthquakes are expected, people make preparations for such emergencies. School children practise earthquake drill. Families keep emergency supplies such as those in the list on the right which comes from California.

Earthquake emergency list

Do you know where to find the following?

Radio (battery powered)
Torch
Extra batteries
Fire extinguisher
First aid supplies
Prescription medicines
Water purification supplies
Stored water
Gas main stop cock
Water main stop cock
Electricity mains switch
Food
Sturdy shoes
Heavy gloves
Blankets
Map showing location of local hospitals and emergency relief centres

Questions for group discussion

You may use worksheet 3 for your answers.

- ☐ *Consider the items on the 'Earthquake emergency list'.*
- ☐ *Why might you need (a) the radio, (b) water purification supplies, (c) heavy gloves, (d) the map?*
- ☐ *Decide how useful each item would be in an earthquake emergency. Rate them for usefulness as follows:*

  3 = essential, 2 = very useful, 1 = useful.

  (You may record your 'usefulness score' in the table on worksheet 3.)
- ☐ *An earthquake is a natural disaster, known in law as an 'act of God'. (a) Suggest other examples of disasters which could happen to your home or neighbourhood. (b) Would the same items on the earthquake emergency list be useful? Can you think of any items to add to the list?*

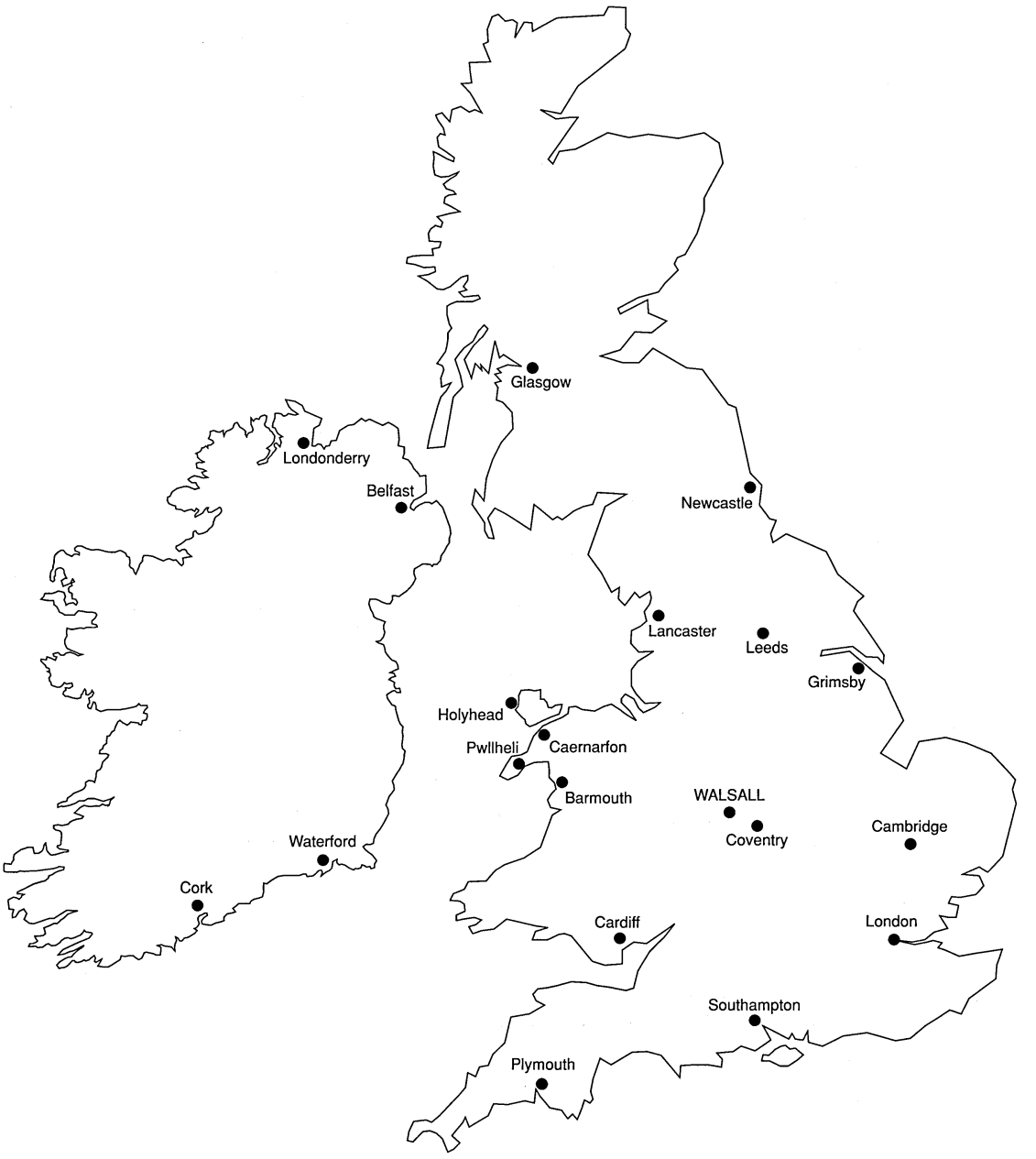
Homework activity *(Use worksheet 3)*

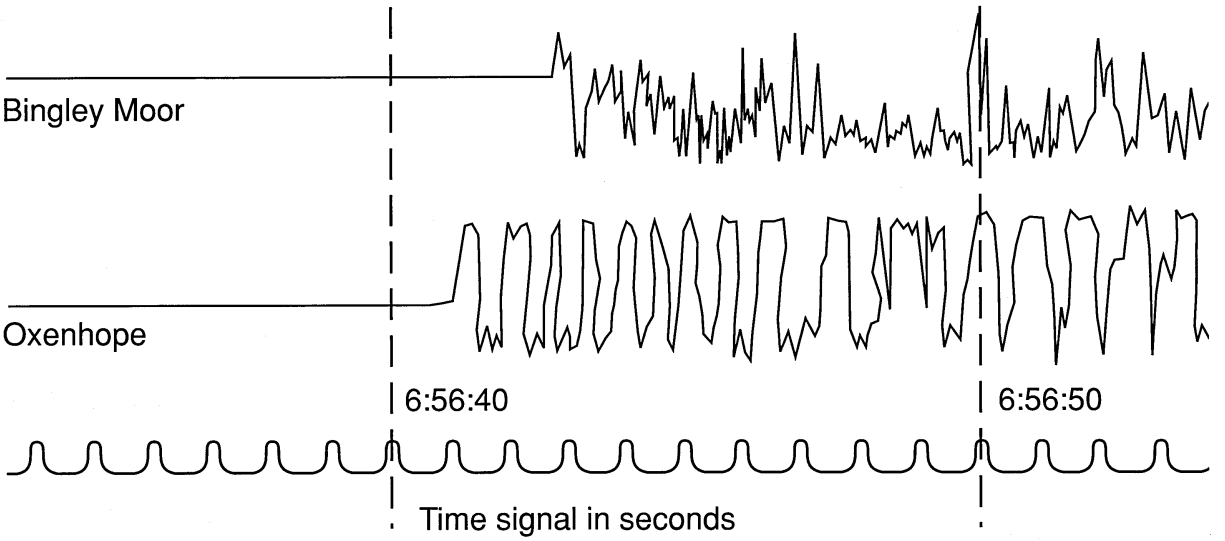
How would you cope with an earthquake?

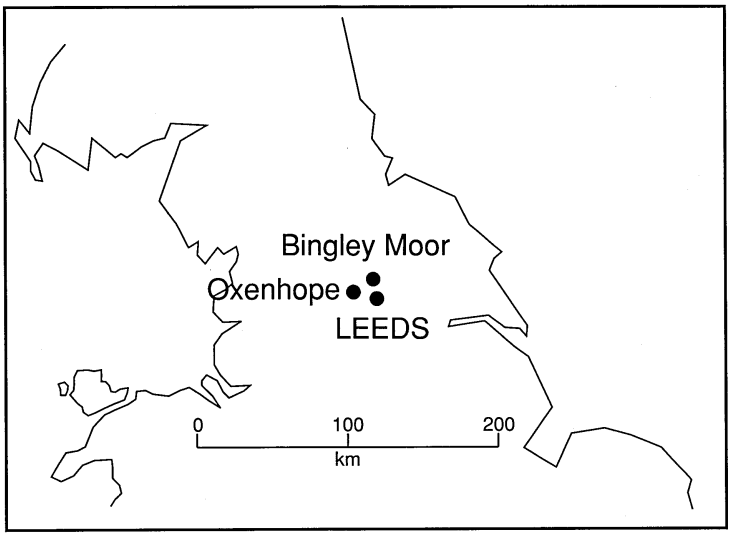
- ☐ Can you find the items on the 'emergency list' in your home? Fill in the checklist on worksheet 3.
- ☐ Survey your kitchen, bedroom and living room for earthquake hazards. Make a list of those you find.

Answers to the questions are given in the *Teachers' Notes.*

Map of the British Isles for drawing isoseismals







Seismograms of the 1984 earthquake

Part C

Name

_____

Earthquake emergency list

Although you are unlikely to experience a strong earthquake in Britain, it is possible for one to occur. In the event of an emergency, do you know where to find the following things?

	Usefulness score	Do you have it?	Where to find it in your home
Radio (battery powered)			
Torch			
Extra batteries			
Fire extinguisher			
First aid supplies			
Prescription medicines			
Water purification supplies			
Stored water			
Gas main stop cock			
Water main stop cock			
Electricity mains switch			
Food			
Sturdy shoes			
Heavy gloves			
Blankets			
Map showing location of local hospitals and other buildings which might be used as emergency relief centres			
Total score			