Lesson 6: Earthquakes
Factsheet for teachers

Purpose of Lesson

Every thirty seconds there is an earthquake somewhere in the world and each year there are approximately 100 earthquakes that cause serious damage. In this lesson pupils will understand that earthquakes, like volcanoes, are primarily (but not exclusively) located on the boundary between two tectonic plates. Pupils will also understand that earthquakes have different strengths, or magnitudes. Some are barely detectable, others cause severe damage to infrastructure and property and result in loss of life.

It is a good idea to watch the interactive guide to earthquakes and tsunamis in conjunction with the Factsheet. Go to the Guardian website:
http://www.theguardian.com/world/interactive/2008/jan/23/earthquakes?intcmp=239

A case study of the San Andreas Fault in North America is provided in the Lesson Plan. Additionally, a separate case study of the 2011 earthquake and tsunami in Japan is also included in this module. This latter can be used in conjunction with Lesson 6, or form a separate, follow-up, lesson as the teacher decides. A pupil activity is also provided with this additional case study.

Vocabulary

This lesson uses the following geographical terms. These should be used and explained to pupils as the lesson is taught. Some of these should already be familiar to pupils.

Plates	The Earth's crust is not one solid piece of land, but is formed of many different pieces or plates. There are eight major plates and many more minor plates. These plates move across the mantle.
Plate boundary	Where tectonic plates meet.
Plate tectonics	The theory of the movement of the plates that make up the Earth's crust.
Constructive plate boundary	(These can also be called divergent boundaries). Here, two plates move apart from one another. As they move apart molten rock rises from the mantle, then cools and hardens to form new crust.
Destructive plate boundary	(Also called convergent boundaries). Here, two plates move towards each other. One plate is then pushed underneath the other.
Transform plate boundary	Two plates move past each other. Friction may cause them to stick, but when they eventually become unstuck, often with a violent jolt, an earthquake results.
Focus	The point at which an earthquake begins deep underground.
Epicentre	The point on the Earth's surface immediately above the focus.
Seismic waves	Vibrations or shock waves that spread out concentrically from the focus. The intensity of the waves decreases with distance.
Magnitude	The strength of an earthquake.
Richter scale	The measurement of the magnitude of an earthquake.
Seismologists	People who study earthquakes.
Seismographs	Instruments that record the magnitude of an earthquake.

Starter Activity:

The Folkestone earthquake: The earthquake of 28th April 2007 had a magnitude of 4.3 on the Richter scale. The earthquake began at 8.19am and lasted for two minutes. It caused damage across Kent and was felt as far away as Calais in France. The worst damage was experienced in Folkestone.

The Kent Fire and Rescue Service took more than 200 calls from people reporting collapsed chimneys and large cracks in the walls of their homes. Gas and electricity supplies were cut off throughout Kent and approximately 100 people had to be evacuated from their homes. A Folkestone resident, Sam Millen, was at home when the earthquake struck. He said, "The whole place was shaking just after 8am, the TV was rocking backwards and forwards, alarms going off, lamps smashed onto the floor, and now the small cracks in the house have got a lot bigger." (Quote from the BBC.) The earthquake resulted in no serious injuries or deaths.

The epicentre was eight miles south west of the coast of Folkestone.

Other earthquakes have been reported in the UK. For example an earthquake with a magnitude of 5.2 on the Richter scale was recorded in Market Rasen in Lincolnshire on 27th February 2008.

The location of earthquakes: Like volcanoes, earthquakes occur primarily along the boundaries of tectonic plates. There is a clear correlation between the location of volcanoes and earthquakes. However, earthquakes also occur less frequently within the body of a tectonic plate. For example, in the UK, 200-300 earthquakes are detected annually. Although a long way from the nearest plate boundary (Mid-Atlantic Ridge) earthquakes occur in the UK as stresses in the crust within a tectonic plate are relieved by movement in pre-existing rock faults.

Richter scale

The Richter scale was devised by Charles F. Richter, an American seismologist, in 1935. It measures the magnitude of an earthquake. It is an exponential scale, so an earthquake with a magnitude of 2 on the Richter scale is actually ten times more powerful than an earthquake with a magnitude of 1. An earthquake with a magnitude of 3 on the Richter scale is ten times more powerful than an earthquake with a magnitude of 2 and so on. The most powerful earthquakes recorded generally have a magnitude of 9, although in theory the Richter scale has no upper limit. One of the largest earthquakes ever recorded was in Chile on 22 May 1960 with magnitude of 9.5.

Richter Magnitude	Effects	Average number of earthquakes per year
Less than 3	Detected by seismometers, but generally not felt by people.	More than 100 000
3	The smallest commonly felt, no damage occurs.	10 000 – 100 000
4	Felt by everyone. Windows rattle, doors open, minor breakage of objects occurs.	2 000 – 12 000
5	Some damage to buildings, plaster cracks, bricks fall.	200 – 2 000
6	A lot of damage to buildings: chimneys fall, houses move on their foundations.	20 - 200
7	Serious damage: walls crack and split. The	3 - 20

	majority of buildings collapse. Bridges twist. There is loss of life.	
More than 8	Severe destruction and loss of life over large areas. The surface waves are clearly visible.	1 or less

In addition to the magnitude of an earthquake its impact on the landscape and people can also be affected by different factors:

- The location of the focus- whether continental or oceanic.
- Distance from the epicentre.
- The type of surface rock (more damage occurs with softer rocks).
- The structure of buildings and whether they are of an earthquake proof construction.
- The population density of a region- more people means a greater likelihood of large numbers of casualties.

Two types of shocks: Different patterns of shocks occur with every earthquake. First to arrive are the 'P waves'. These move deep underground, beneath the surface of the Earth. These can be felt as a rumbling and can warn people of the impending quake. The next waves to hit are the 'S waves'. S waves travel on the surface and do the most damage. Some move buildings up and down vertically, others move sideways twisting buildings off their foundations.

Can earthquakes be predicted? There is no reliable method of predicting the exact timing of earthquakes. On-going research is investigating a number of different avenues. For example, the occurrence of minor earthquakes or 'foreshocks' in the days before a major quake; changes in the levels of gases emitted from the ground and even changes in the behaviour of animals preceding an earthquake are all under consideration.

Earthquake proof buildings: A building can be made earthquake proof in different ways. It will often have deeper foundations than conventional buildings. The base of a building can also be constructed to move semi-independently to its superstructure, reducing the shaking caused by a quake. The use of shock absorbers, counterweights and cross braces can also dampen seismic energy. Shatter-proof glass can also be added to windows.

What to do in the event of an earthquake:

- If you are outside, move away from power lines, trees and buildings.
- If you are inside, stay away from windows, mirrors, cupboards and shelves.
- Take cover under a sturdy table or desk and hold on to it.
- You can also stand under a doorway; they are often one of the strongest parts of a house.
- Do not leave a building while the shaking continues and be prepared for possible shaking after the main quake.
- If you are in a high building, stay out of the stairways and do not use the lifts.
- A family can prepare for an earthquake by having flashlights, helmets and sturdy shoes, a first aid kit, a fire extinguisher, bottled water, tinned food and a tin opener.
- Stay calm.

The Big One: This is a hypothetical earthquake with a magnitude of 8 or greater that is expected to happen along the San Andreas Fault. An earthquake of this magnitude would produce devastation up to 200 km from the epicentre, especially in the urban areas of Palm Springs, Los Angeles and San Francisco. As a result, most of the public buildings in Los Angeles have been retrofitted with steel reinforcement, and hundreds of bridges have been strengthened. Geologists' predictions vary as to the exact magnitude and date of the Big One, but the consensus is that a Big One of at least

magnitude 7 could strike California within the next few decades. It is also estimated that a Big One may cause thousands of fatalities.