Natural Hazards

Tectonic Hazards
A natural hazard is an extreme natural event or process that causes loss of life and/or extreme damage to property and creates severe disruption to human activities.

Figure 3.3 World distribution of earthquakes.

Figure 3.4 World distribution of volcanoes.
**Structure of the earth**

- **Crust**: The crust is the outer layer of the earth. It is a thin layer between 0-60km thick. The crust is the solid rock layer upon which we live. There are two different types of crust: **continental crust**, which carries land, and **oceanic crust**, which carries water.

- **Mantle**: The mantle is the widest section of the earth. It has a diameter of approximately 2900km. The mantle is made up of semi-molten rock called magma. In the upper parts of the mantle the rock is hard, but lower down, nearer the inner core, the rock is soft and beginning to melt.

- **Core**: The inner core is in the centre of the earth and is the hottest part of the earth. The inner core is solid. It is made up of iron and nickel with temperatures of up to 5500°C. With its immense heat energy, the inner core is like the engine room of the Earth. The outer core is the layer surrounding the inner core. It is a liquid layer, also made up of iron and nickel. It is still extremely hot here, with temperatures similar to the inner core.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Depth</th>
</tr>
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<tbody>
<tr>
<td>Crust</td>
<td>0-60km</td>
</tr>
<tr>
<td>Mantle</td>
<td>2900km</td>
</tr>
<tr>
<td>Core</td>
<td>2900-5150km 5150-6370km</td>
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</tbody>
</table>
The tectonic plates are moving in different directions. The movements have different effects on the landscape of the Earth.

- Plates that are moving in opposite directions form a **constructive** boundary.
- Plates that move towards each other form either a **destructive** boundary or a **collision** boundary.
- Plates sliding by each other form a **conservative** boundary.

**Plates and plate boundaries**

The earth’s crust is broken up into pieces. These pieces are called plates. Heat rising and falling inside the mantle creates **convection currents**. The convection currents move the plates. The movement of the plates, and the activity inside the earth, is called **plate tectonics**.

Plate tectonics cause earthquakes and volcanoes. The point where two plates meet is called a **plate boundary**. Earthquakes and volcanoes are most likely to occur either on or near plate boundaries.
<table>
<thead>
<tr>
<th>Plate Boundary</th>
<th>Diagram</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tensional / Constructive</strong> (divergent) plate boundaries</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td>Constructive plate boundaries occur when two plates move away from each other</td>
<td>North American and Eurasian Plate</td>
</tr>
<tr>
<td><strong>Compressional / Destructive</strong> (subduction zones) plate boundaries</td>
<td><img src="image2.png" alt="Diagram" /></td>
<td>Destructive plate boundaries occur when an oceanic plate is forced under (or subducts) a continental plate</td>
<td>Pacific Plate and the Eurasian Plate</td>
</tr>
<tr>
<td><strong>Conservative</strong> (transform faults) plate boundaries</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td>Conservative plate boundaries occur when two plates slide past each other.</td>
<td>North American Plate and the Pacific Plate</td>
</tr>
<tr>
<td><strong>Collision</strong> plate boundaries</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td>Collision plate boundaries occur when two continental plates move towards each other.</td>
<td>Indo-Australian and the Eurasian Plate</td>
</tr>
</tbody>
</table>

Plates behave differently at different plate boundaries:

- At a **constructive** or **divergent** boundary the plates move apart.
- At a **destructive** or **convergent** boundary the plates move towards each other.
- At a **conservative** or **transform** boundary the plates slide past each other.
Complete the table below as a revision task without referring to any books!

<table>
<thead>
<tr>
<th>Type of plate margin</th>
<th>Description of changes</th>
<th>Earthquake/volcanic activity</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergent (oceanic and continental)</td>
<td></td>
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<tr>
<td>Convergent (two continental)</td>
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<tr>
<td>Divergent on land</td>
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<td></td>
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<tr>
<td>Divergent under the ocean</td>
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<td></td>
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<td>Transform</td>
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</table>
Volcanoes

Why do people live close to volcanoes?

Volcanoes have a wide range of effects on humans. These can be problematic or beneficial. It is usually the destructive nature of volcanoes which is more widely documented. However, many people rely on volcanoes for their everyday survival. Today, many millions of people live close to volcanoes for this very reason.

People live close to volcanoes because Geothermal energy can be harnessed by using the steam from underground which has been heated by the Earth’s magma. This steam is used to drive turbines in geothermal power stations to produce electricity for domestic and industrial use. Countries such as Iceland and New Zealand use this method of generating electricity.

Volcanoes attract millions of visitors around the world every year. Apart from the volcano itself, hot springs and geysers can also bring in the tourists. This creates many jobs for people in the tourism industry. This includes work in hotels, restaurants and gift shops. Often locals are also employed as tour guides.

Lava from deep within the earth contains minerals which can be mined once the lava has cooled. These include gold, silver, diamonds, copper and zinc, depending on their mineral composition. Often, mining towns develop around volcanoes.
Volcanic areas often contain some of the most mineral rich soils in the world. This is ideal for farming. Lava and material from pyroclastic flows are weathered to form nutrient rich soil which can be cultivated to produce healthy crops and rich harvests.
Fill this table in from memory when you have studied and learnt the above diagram

<table>
<thead>
<tr>
<th></th>
<th>Destructive composite - oceanic/continental</th>
<th>Hot spot shield</th>
<th>Constructive</th>
<th>Destructive composite - continental</th>
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</thead>
<tbody>
<tr>
<td>Margin type</td>
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<tr>
<td>Volcano type</td>
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<td>Eruption products</td>
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<tr>
<td>Diagram of volcano</td>
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<tr>
<td>Detail on formation</td>
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<tr>
<td>Examples</td>
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</table>
Nevado del Ruiz is the northernmost of several Colombian stratovolcanoes in the Andes Volcanic Chain of western South America. The Andean volcanic belt is generated by the eastward subduction of the Nazca oceanic plate beneath the South American continental plate. Typically, such stratovolcanoes generate explosive Plinian eruptions with associated pyroclastic flows that can melt snow and glaciers near the summit, thus producing devastating lahars.

After nearly a year of minor earthquakes and steam explosions from Nevado del Ruiz, the volcano exploded violently on November 13, 1985. The initial blast began at 3:06 p.m., and two hours later pumice fragments and ash were showering down on Armero. However, the citizens of Armero remained calm. They were placated by reassuring messages from the mayor over radio, and from a local priest over the church public address system. Nevertheless, the Red Cross ordered an evacuation of the town at 7:00 p.m. However, shortly after the evacuation order the ash stopped falling and the evacuation was called off.

At 9:08 p.m., just as calm was being restored, molten rock began to erupt from the summit crater for the first time (all previous eruptions were steam explosions). The violent ejection of this molten rock generated hot pyroclastic flows and airfall tephra that began to melt the summit ice cap. Unfortunately, a storm obscured the summit area so that most citizens were unaware of the pyroclastic eruption. Meltwater quickly mixed with the erupting pyroclastic fragments to generate a series of hot lahars. One lahar flowed down the River Cauca, submerging the village Chinchina and killing 1,927
people. Other lahars followed the paths of the 1595 and 1845 mudflows. Travelling at 50 kilometers per hour, the largest of these burst through an upstream dam on the River Lagunillas and reached Armero two hours after the eruption began. Most of the town was swept away or buried in only a few short minutes, killing three quarters of the townspeople.
CASE STUDY Nevado del Ruiz 1985 - a volcano in an LEDC

GET STARTED

Find a map of Colombia that shows its physical features in an atlas or on the Internet. List five facts about the relief and drainage of the country, for example, the height of the mountains, the names of some of the rivers.

Nevado del Ruiz is a stratovolcano in the mountain range of the Andes. It is the highest Colombian volcano with a history of violent activity. The Nevado del Ruiz was produced by subduction of the oceanic Nazca Plate beneath the South American Plate. Through the centuries a series of movements have occurred along this plate boundary, leading to the formation of the Andes fold mountains. Nevado del Ruiz has been called the "sleeping giant" by the local towns around it. It had been a dormant volcano for nearly 150 years when, in 1985, the volcano erupted, and it was a result of which 30,000 people were killed.

The eruption: 13 November 1985

After nearly a year of minor earthquakes and steam explosions from the crater of Nevado del Ruiz, the volcano exploded violently.

Timeline

3:00 p.m.: Premelt fragments and ash were thrown from the side of the vent. These showered down on the town of Armero at the foot of the volcano.

7:00 p.m.: The Red Cross ordered an evacuation of the town. Shortly after the evacuation order, the ash stopped falling and the evacuation was called off.

9:00 p.m.: The eruption began as lava started to erupt from the summit crater for the first time. The eruption was accompanied by heavy rainfall. Approximately 20 million cubic metres of hot ash and rocks were thrown into the air across the snow-covered glacier. These materials were transported across the snow pack by pyroclastic flows and lava flows, hot, turbulent clouds of gas and ash. The hot flows caused rapid melting of the snow and ice, and created large volumes of water that swept down canyons leading away from the summit. As these floods of water descended, they picked up loose debris and soil from the valley floors and walls, growing both in volume and density, to form hot lahars. In the river valleys further down the volcano's slopes, the lahars were as much as 40 m
drick and travelled at velocities as fast as 50 km/h.

Key Terms

Lahar - a type of mudflow comprised of pyroclastic material and water that flows down from a volcano, typically along a river valley.

Pyroclastic flows - avalanches of hot volcanic debris.

FACT FILE

Although not the most violent explosion, Nevado del Ruiz was the second most destructive eruption of the 20th century, following Mount Pelée in 1902.

11:36 p.m.: One of the lahars reached Armero. In a few short minutes most of the town was swept away or buried in a torrent of mud and boulders. One lahar flowed down the River Cauca, submerging the village of Chiricora and killing 1927 people.

What were the effects of the eruption on people and the landscape?

The effects of the eruption can be divided into primary and secondary types. Primary effects are those that are a direct result of the eruption occurring in that location. Secondary effects include those impacts that result indirectly from the event.

Primary effects

- 5000 people were injured.
- The temperature of the lahars served as a fertile breeding ground for all kinds of fungi and bacteria. Some survivors who had minor cuts were killed by the infections, which could not be treated with local antibiotics.
- Roads were blocked and rescue workers found it difficult to reach survivors from the deep mud.
- The eruption cost Columbia US $7.7 billion (20% of the country's GDP at the time).

Secondary effects

- The release of dust and gases into the atmosphere caused a significant reduction in global temperatures.
- The eruption caused widespread environmental damage, including the destruction of agricultural land.
- The eruption had a devastating effect on the local economy, with many people losing their homes and livelihoods.

Activities

1. Use a diagram to explain the causes of the 1985 eruption of Nevado del Ruiz.
2. Make a timeline to show the events that took place from the moment of the eruption until the lahar reached Armero. Indicate on your timeline which are primary and which are secondary effects.
3. Describe how the effects of the eruption affected the landscape of the area.
4. Why did the earthquake cause so many deaths?
5. What do you think was the impact of the eruption on:
   a. the lives of people who lived in the area of Armero?
   b. the lives of people of the rest of Colombia?
   c. the environment?
   d. the economy?
   e. the political stability?
   f. the health of the region?
   g. the future of the community?
   h. the future of the environment?
   i. the future of the politics?
   j. the future of the economy?
   k. the future of the health?

Research Link

Use the Internet to find out what has happened since the eruption to the people and the environment around Armero.

Plenary Activity

"If the slopes of Nevado del Ruiz had not been covered by glaciers the effects of the eruption in 1985 would have been far less severe for the people and the landscape. Discuss this statement with a partner."
Mt Etna

Mt Etna Volcano is one of the world’s most active volcanoes. It has been erupting since several million years. Mt Etna is one of the greatest and beautiful volcano adventure tour destinations in Sicily, beside many other which can be easily enjoyed from our charming village of Taormina. This volcano has more than 400 craters, split all over the Catania county. To the ancient Greeks, Mount Etna was the realm of Vulcan, god of fire, and the home of the one-eyed monster known as the Cyclops. Etna offers skiing in the Winter months and breathtaking hikes in the woods during the Summer. There are also a number of smaller peaks on the slopes of Etna, and some interesting caverns. Since Etna is a strato volcano, with relatively cool lava temperatures and numerous openings (vents), nobody ever knows precisely where on its vast surface the next eruption will be.
CASE STUDY  Mount Etna 2002 – a volcano in an MEDC

GET STARTED

What caused Etna to form?

Etna is a strato-volcano, which has formed as a result of repeated volcanic eruptions that have built up layers of lava and ash to create a cone. Figure 3.18 shows the cause of the formation of Mount Etna.

Figure 3.18 The formation of Etna.

Sicily is located just south-west of the Italian mainland. It is the largest island in the Mediterranean basin. It is one of the poorest areas of Italy, but the fertile soil and a long, hot growing season mean that agriculture is an important part of the economy here. A newer form of income for the local people is the more recent development of a tourist industry, which includes skiing on the upper slopes of the volcano.

Fact file

Largest volcano in Europe. Height: 3359 m.

Mount Etna is one of the most active volcanoes in the world and is in an almost constant state of eruption.

Figure 3.20 Erupting Etna.

The eruption

Mount Etna erupted throughout November 2002.
A series of earthquakes, measuring up to 4.3 on the Richter scale, accompanied several explosions that blackened the sky above the mountain. Clouds of gas and ash were forced from two vents, one a new one, in the side of the volcano. This was followed by magma, which was thrown more than 100 m into the air in a spectacular display. The lava then began to run quickly down the mountainside, forming two separate flows. Ash fell continuously onto the city of Catania and drifted as far south as Libya.

The impact of the eruption

The earthquake damaged more than 100 homes in Santa Venerina and holiday homes were taken over by the local authorities to house displaced people. Residential areas such as the town of Linguaglossa were evacuated because of the threat of the lava flow. One thousand people had to leave their homes. Schools in the town were shut down, although the church remained open for people to pray. Villagers also continued their tradition of parading their patron saint through the streets to the railway station, to try to ward off the lava flow.

The airport at Catania was closed for 4 days because of the ash that covered the runway and threatened to clog up the aircraft engines. The skiing season was about to start, but the area was swamped by the flowing lava. It engulfed a restaurant and pushed over three ski-lift pylons. It also destroyed hundreds of hectares of forest on the slopes of the volcano.

The response to the eruption

The Italian government declared a state of emergency in parts of Sicily during the eruption. Rescue workers battled to divert the lava that threatened to engulf a scientific monitoring centre at the foot of the mountain. The army used bulldozers to crack the tarmac and build barriers in a car park near the centre, in an attempt to create a channel that would deflect the lava away from populated areas. Emergency workers dug channels in the earth in an attempt to divert the northern flow away from the town of Linguaglossa. A ship equipped with a medical clinic was positioned off Catania to be ready in case of emergency.

The businesses of 300 families were affected by the eruptions and the Italian government gave six weeks for villagers to help them get through the crisis and more than US $8m (£5.6m) in immediate financial assistance.

RESEARCH LINK

Has Etna erupted recently? Is there still a tourist industry in the area?

ACTIVITIES

1. Why do you think people continue to live on the slopes of Etna, even though it continuously erupts for months at a time?

2. Make a list of all the people whose jobs were affected by the eruption. How have some of them tried to compensate for their loss of income?

3. Think of five questions you would need to ask about volcanoes to make a comparison between the eruption of Nevado del Ruiz (ERCO) and the eruption of Etna (MEDC). This should include the effects of the volcano on the landscape and on people.

4. With a partner, compare your questions and agree on the six best questions.

5. Use your questions to compare the eruptions of the two volcanoes by drawing up a table to show the similarities and differences.
Volcanologists - people who study volcanoes - are skilled at predicting the likelihood of an eruption. However, it is difficult to pinpoint when an eruption will happen.

- The movement of magma may be detected, but often no eruption occurs. Instead it cools below the surface.
- Monitoring potential eruptions is expensive.
- With many volcanoes erupting only every few hundred years, it's not possible to monitor every site.
Earthquakes

Earthquakes are vibrations of the earth’s crust caused by movement at plate boundaries and major fault lines. The red areas on the map are where earthquakes are most frequent.

Main Concepts

Earthquakes occur along faults, which are large cracks in the earth’s crust. Most of these are associated with the larger plate boundaries, along which the largest earthquakes usually occur.
They are caused by the sudden jerking movements of the fault, either laterally or vertically, and are almost impossible to predict.

An earthquake is the shaking and vibration of the crust due to movement of the Earth’s plates (plate tectonics). Earthquakes can happen along any type of plate boundary.

Earthquakes are caused when the tension is released from inside the crust. This happens because plates do not move smoothly - sometimes they get stuck. When this happens a great deal of pressure builds up. When this pressure is eventually released, an earthquake tends to occur.

The point inside the Earth’s crust where the pressure is released is called the focus. The point above the focus, on the Earth’s surface is called the epicentre.

In an earthquake, energy is released in the form of waves. These are called seismic waves. The waves spread out from the focus. The strongest waves are found near the centre of the earthquake. This means that the most severe damage caused by an earthquake will happen close to the epicentre.

The diagram above illustrates how the movement of two plates at the plate boundary creates pressure deep inside the Earth. This is the focus. This pressure travels up to the Earth’s crust and escapes at the epicentre of the earthquake. The pressure, released at the epicentre, travels outwards in all directions in rings (seismic waves). The waves are felt most strongly at the epicentre, becoming less strong as they travel further away.
Earthquakes are measured in two ways:

- The **Richter scale** measures the magnitude of an earthquake using an instrument called a seismograph. The Richter scale is logarithmic, meaning that an earthquake measuring 7 is 10 times more powerful than one measuring 6, and 100 times more powerful than one measuring 5.

- The **mercalli scale** measures the damage caused by an earthquake. It rates each quake from I to XII, depending on how much damage was done, and is dependent not only on the magnitude of the earthquake but also the **depth** of the earthquake.

The point at which an earthquake actually begins, deep below the earth's surface is called the **focus**. If the focus is deep then the effects of the earthquake may be less as the shockwaves have more rock to move through. Obviously this also depends on what type of rock it is. The point directly above the focus, on the earth's surface, is called the **epicentre**. The effects of the earthquake are usually worst here, and then radiate out from this spot.

**Effects of Earthquakes**

The effects of an earthquake can be easily split up into two sections. **Primary effects** are those that occur immediately as the earthquake happens. These include buildings collapsing, roads and bridges being destroyed and railway lines being buckled. All occur due to the shaking of the ground.

**Secondary effects** are the subsequent effects of the quake, and can be even more devastating than the primary ones. The **main secondary effects are**:

- **Fires**: usually from ruptured gas lines. This was the main cause of death and damage after the San Francisco earthquake in 1906.

- **Tidal waves**: A tidal waves caused by an earthquake is called a tsunami. They can travel very quickly across entire oceans, before engulfing land 1000's of miles away. The 1964 Alaskan earthquake caused considerable damage in several Californian coastal areas. Although Los Angeles has escaped so far, its is still considered to be a tsunami hazard prone area

- **Landslides** can often be triggered by earthquakes, causing huge amounts of material to be moved very quickly. This is actually what occurred just before the volcanic eruption on Mt. St. Helens. They are most likely to occur where the land is steep, saturated or weak.

- **Diseases** can spread very quickly in the unsanitary conditions often left behind by massive earthquakes. Water becomes contaminated very quickly, and in Less Economically Developed Countries (LEDG's) especially; access for the medical services can be badly hampered by the
damage caused by the quake. The most common diseases to be associated with earthquakes are therefore water-borne ones like cholera and typhoid.

<table>
<thead>
<tr>
<th><strong>Table 3.4 Effects of an earthquake</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Ground shaking</strong></td>
</tr>
<tr>
<td><strong>Landslides, rock and snow avalanches</strong></td>
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<tr>
<td><strong>Tsunamis</strong></td>
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<tr>
<td><strong>Liquefaction</strong></td>
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</table>
The Northridge earthquake of 17 January 1994 struck a modern urban environment, generally designed to withstand strong earthquakes. There were relatively few casualties, but the economic cost was high, with losses estimated at US $20 billion.

The earthquake occurred beneath the San Fernando Valley on a deeply buried blind fault at 4:32 a.m. local time on 17 January 1994. Northridge is located about 20 km north-west of Los Angeles. This earthquake measured 6.7 on the Richter scale. The focus depth was 15 km. The duration ranged from 10 seconds to 30 seconds. Fifty-seven people were killed and 8 000 injured. The fact that the earthquake occurred early in the morning and on a public holiday minimised the death toll.

There were nearly 15 000 aftershocks that occurred after the main earthquake. For example, a magnitude 5.5 aftershock occurred about 1 minute after the main shock and a magnitude 5.6 earthquake occurred 11 hours later. Aftershocks can trigger the collapse of structures weakened by the main shock.

Structural damage
- Most casualties and damage occurred in multi-storey wood-frame buildings (for example, the three-storey Northridge Meadows apartment building). In particular, buildings with a weak first floor (such as those with parking areas on the bottom) performed poorly.
- The Northridge earthquake caused extensive damage to parking structures and freeway overpasses.
- The Northridge earthquake triggered landslides in surrounding mountain areas. These landslides blocked roads and damaged water lines and also damaged homes, particularly in the Pacific Villas area.
- Numerous fires were also caused by broken gas pipes damaged by houses shifting off foundations or by unsecured water heaters falling over. A fire devastated an area of trailer homes in the San Fernando Valley. Several underground gas and water mains were severed.

The scoreboard at Anaheim Stadium collapsed onto several hundred seats. Fortunately, the stadium was empty at the time, due to the time of day the earthquake occurred.

 liquefaction occurred amongst some alluvium in the upper San Fernando Valley.

The area was declared a federal disaster by President Clinton and hundreds of workers from the Federal Emergency Management Agency (FEMA) were deployed to southern California to help the community there recover. More than 800 000 individuals applied for state and federal disaster assistance, and FEMA spent millions of federal money helping the area recover.

Predicting an earthquake
Researchers in 2000 predicted that Southern California was much more likely to suffer an earthquake the size of the Northridge one than Northern California by 2021. The problem is that they cannot predict when or where the earthquake will happen.

The United States Geological Survey (USGS) have been investigating whether it is possible to predict earthquakes for over 30 years. Scientists analyse data to work out the likelihood of fault movements in specific areas using new information about prehistoric earthquakes, locations of hidden faults, and an increasing database of satellite-based GPS data of the Earth’s crust movement.

ACTIVITIES
1. Draw a sketch map showing the location of the Northridge earthquake and label it with examples of the effects of the earthquake. Indicate whether they are primary or secondary effects.
2. Imagine an earthquake of 7.0 on the Richter scale occurred with its epicentre in your home area. List the effects that the earthquake would have on your surrounding area. Divide them into primary and secondary effects and try to give actual examples of structures that would be affected.
3. Services and cars are important to most of us in our daily lives. When disaster strikes many people have to go without both. How would the following disruptions affect you?
   - No power
   - No natural gas
   - No water
   - Inaccessible roads and no public transport.
4. What groups of people would experience special difficulty in confronting these disruptions?
CASE STUDY Sichuan, China 2008 – an earthquake in an LEDC

GET STARTED

If you were to experience an earthquake while inside your house, what three items would you grab on your race to get outside? Think about what you would need to survive if your whole area was devastated.

On Monday, 12 May 2008 at 2.28 p.m. local time, an earthquake measuring 7.9 on the Richter scale struck the province of Sichuan in southern China. People were at work, in school and out shopping, when an event that lasted only 2 minutes killed 69,180 people and changed millions of lives forever.

Fact file
China
- Population: 1,373,350,000.
- Fastest-growing population in the world for last 25 years.

Agricultural damage
- Uplifted systems for 170,000 hectares of paddy fields
- Over 300,000 greenhouse buildings destroyed
- 7.3 million m² of livestock barns collapsed

Infrastructure damage
- Over 15,000 schools collapsed
- 5.8 km of pipes damaged
- 85% water tanks collapsed
- 1300 water treatment works destroyed

Schools built in rush
According to Chinese government experts, the collapse of so many schools in the Sichuan earthquake was probably due to construction flaws occurring in a rush to build schools. This is the first time that officials have admitted that building standards may have contributed to the deaths of many children.

ACTIVITIES
1. Make a fact file of the Sichuan earthquake. Include information about its causes and the primary and secondary effects that were caused.
2. Locate Sichuan on an atlas map of China. Use the information in this section to explain why people suffered so badly after this earthquake. Write sections about homes, jobs, health.

THINK ABOUT IT
How might China’s one child policy cause particular hardship for people in Sichuan Province?

PLINNARY ACTIVITY
If you had been in charge of the relief work in Sichuan Province, what would have been your priorities and how would you have put them into action?
The Impact of Natural Hazards

**MEDC's v LEDC's**

Natural hazards will affect More Economically Developed Countries (MEDC's) in a differing way to those that occur in Less Economically Developed Countries (LEDC's).

- **Health Care:** MEDC's have the medical resources and money to quickly get appropriate aid to areas after a natural disaster. LEDC's often have to rely on aid from overseas as their health system, which is inadequate. This overseas aid takes time to arrive, which could mean far more casualties.

- **Emergency Services:** In MEDC's who have a volcanic or earthquake risk, such as Japan and New Zealand, there are well thought out emergency procedures. Practices in schools and places of work mean that people know what to do it the event of a natural disaster. The Government's and military have special emergency plans to help with the situation. Often LEDC's do not have these emergency plans, and so far more damage can be done before the emergency services reach the stricken area.

- **Building Technology:** Countries such as Japan and the United States have been at the forefront of developing buildings that have more chance of resisting an earthquake. Most houses in San Francisco are made of wood, to make them more flexible and allow them to move with the quake. Larger skyscrapers are built with flexible foundations, which literally allow them to sway during a quake, rather than being rigid and falling down. Many countries in areas prone to natural hazards have building codes to say where they can and cannot build, and how high the buildings can be. New Zealand is a good example of where this occurs. LEDC's don't tend to have the technology available or money to pay for it, and so often their buildings are very susceptible to earthquakes.

- **Scientific Prediction:** Scientists work throughout the world, trying to predict earthquakes and volcanoes. So far they have found it very difficult to predict earthquakes, although scientists monitoring the San Andreas Fault in California have planted a huge number of seismographs in the ground to try to detect even the faintest of tremors. Volcanoes generally are easier to predict, although the specific time of the eruption is not so easy to do. Scientists can measure changes within the mountain that helps them to predict that the volcano is going to erupt. This usually allows the Local Authorities sufficient time to evacuate people from the danger area (as seen at both Mt. St. Helens and Mt. Pinatubo). However they still find it very difficult to accurately predict the size of the eruption. MEDC's do tend to have more investment for this type of research and development than LEDC's.

**Recovery:** MEDC's tend to be able to recover quickly from a natural disaster, due to having the investment and technology needed to return the area to as good as new as soon as possible. Because LEDC's often have to rely on aid from overseas, this quick recovery is often impossible for them.
Shear wall: reinforced concrete walls provide strength and resist rocking from earthquakes.

Shear core: reinforced concrete (concrete set with steel rods) is used to provide a very strong core to the building.

Moat: there is a gap between the ground and the foundations, so the shock travels through the base isolators.

Cross-bracing: diagonal steel bars reinforce walls.

Base isolator: like shock absorbers, made from alternating layers of steel and rubber; these dampen down the impact both up and down the structure and also from side to side.

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**Figure 3.39 Earthquake proof building.**

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C. In the attic, nail plywood to the ceiling joists around the chimney for protection against falling bricks.

D. Remove heavy items from the walls above beds. Locate beds away from plate-glass windows.

E. Use plywood panels to strengthen the walls that surround the crawl space beneath a house.

F. To help the house withstand shaking, use metal connectors to strengthen joints in the house’s frame.

G. To reduce the risk of fire, strap the water heater to the wall to prevent it from toppling over and breaking a gas line. Learn how to shut off the gas, water and electricity.

H. Bolt the house to its concrete foundation to prevent it from slipping off.

B. Secure brick chimneys with light, metal brackets.

A. To prevent bookshelves, cabinets and tall dressers from toppling, fasten them to wall studs with L-shaped brackets.

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**Figure 3.40 Hazard spotting in the home.**
Tropical Storms

A tropical storm is a large depression or cyclone that forms over tropical seas and moves away from the equator.

- Tropical cyclones are like engines that require warm, moist air as fuel. So the first ingredient needed for a tropical cyclone is warm ocean water. That is why tropical cyclones form only in tropical regions where the ocean is at least 27°C for at least the top 60m below the surface.

- The second ingredient for a tropical cyclone is wind. In the case of hurricanes that form in the Atlantic Ocean, the wind blowing westward across the Atlantic from Africa provides the necessary ingredient. As the wind passes over the ocean's surface, water evaporates (turns into water vapour) and rises. As it rises, the water vapour cools, and condenses back into large water droplets, forming large cumulonimbus clouds. These clouds are just the beginning!

- Happen between May and November in the northern hemisphere and November and April in southern hemisphere.
CASE STUDY Hurricane Katrina, USA 2005

How could such a disaster happen in the USA?

The USA is one of the most economically developed countries in the world. It has many scientists monitoring the risk of disasters across the country and some of the most sophisticated levels of technology anywhere in the world. The Gulf of Mexico coast is famous as an area where tropical storms threaten for five months of the year. How then, did Hurricane Katrina cause such major and long-lasting devastation in the area around New Orleans?

Hurricane Katrina began as a very-low-pressure weather system, which strengthened to become a tropical storm and eventually a hurricane as it moved west and reached the Florida coast on the evening of 25 August 2005.

Measure a height of fun in your classroom. Make a list of all the damage that would be done if your school or college was flooded to this depth. What would be destroyed?

Figure 1.4.8 The track of Hurricane Katrina.

Table 3.5 Timetable of Katrina’s approach

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 August</td>
<td>Tropical depression formed off the south-western Bahamas.</td>
</tr>
<tr>
<td>24 August</td>
<td>Ungraded to tropical storm and given name Katrina.</td>
</tr>
<tr>
<td>25 August</td>
<td>Strengthened to become a hurricane and made landfall in the morning north of American in Florida.</td>
</tr>
<tr>
<td>26 August</td>
<td>Storm reached New Orleans as the rear winds of the Gulf of Mexico reached Category 5 status.</td>
</tr>
<tr>
<td>27 August</td>
<td>Storm first clashed in New Orleans and reached Category 5 intensity as it crossed the Gulf towards Mexico.</td>
</tr>
<tr>
<td>28 August</td>
<td>Reached its peak strength of Category 5, with maximum winds of 264 km/h and a central pressure of 902 mb. Turns north and approaches the US coast.</td>
</tr>
<tr>
<td>29 August</td>
<td>Makes its second landfall of 6:10 a.m. at the southern edge of New Orleans.</td>
</tr>
<tr>
<td>30 August</td>
<td>Hurricane follows the course of the Mississippi, being downgraded to a tropical depression near Clarksdale, Tennessee.</td>
</tr>
<tr>
<td>31 August</td>
<td>Remnants of the storm reach the Great Lakes, causing heavy rain and high winds.</td>
</tr>
</tbody>
</table>

Service issued a bulletin predicting that the New Orleans area would be uninhabitable for weeks after devastating damage caused by Katrina.

On Sunday 28 August about 1.2 million people were awared with evacuation orders. Fifty-seven emergency shelters were established in coastal areas. Motorists jammed as people obeyed the order to leave. The Louisiana Superdome in the centre of New Orleans was set up for people who could not leave the city. There were not enough buses and coaches to evacuate all the vulnerable communities from the city and public transport, including train services, had shut down.

Impacts on people

- The levee and flood walls that protected New Orleans were breached in 13 different places, allowing water to flow the city up to 3 m deep.
- Flooding was made worse by the heavy rain (250 mm per day). It is estimated that over 90% of the city was under water.

Looters take advantage of New Orleans mess

"It’s insanity," says a woman watching theft in the French Quarter.

In the flood-damaged streets of New Orleans, looters took advantage of the situation by stealing everything from the stores. In some cases, people were seen carrying goods without paying. At a Walgreens drug store in the French Quarter, people were walking out with grocery items and clothes filled with soft drinks, chips and diapers.

(Source: Associated Press)

ACTIVITIES

1. Explain why the hurricane last long time as it travelled north through the central USA.
2. Draw up a timetable to show the damages that were given to the people of New Orleans.
3. Explain the immediate and secondary effects of the hurricane. What reasons were given to explain the high number of deaths from this hurricane?
4. Many cities of the US federal administration said federal authorities would have made a better job of responding to the disaster if the majority of the victims had been black people rather than poor black people. Why is it that poor people are often hit hardest by natural hazards?

RESEARCH LINK

Flood control barriers can sometimes cause more flooding than they prevent. Use the internet to find out why this might be so.
CASE STUDY Cyclone Nargis, Myanmar 2008

Are the deaths from tropical storms caused by being in the wrong place at the wrong time?

GET STARTED

Using an atlas, find facts about the physical geography of Myanmar. What is this country's former name?

In a country with the same size population as the UK there is only one person in a thousand with access to the internet. Myanmar ranks 122nd in a list of the world's 50 poorest countries and the last thing it needed was a disaster to add to those it faces.

Environmental damage in Myanmar

As is often the case with the world's poorest countries, the environment suffers in order to make money. In Myanmar's case this has meant the destruction of mangrove swamps. In a 10-year period 10 percent of its mangroves in the area affected by Cyclone Nargis. These mangrove swamps should serve as natural barriers to stop storm surges. Their roots absorb wave energy. In the 2004 Boxing Day tsunami, villages with intact mangrove swamps had suffered significantly less death and destruction than those that had lost theirs.

The effect of the storm

On 2 May strong winds had reached speeds of over 217 km/h and hit the west delta of the Irrawaddy river in Myanmar, bringing torrential rains and storm surges to the very low-lying and agricultural delta.

The UN estimated that 1.5 million people were severely affected by Cyclone Nargis, with official figures estimating the death toll at over 125,000 people. Some reports suggest 15 percent of buildings were destroyed, and all suffered significant damage, including roads being ripped off. Millions of people were made homeless as a result of the storm. The local infrastructure was unable to withstand the storm, with reports that sewage systems were overwhelmed, causing leakage which contaminated rice fields and caused disease.

Electricity lines were also destroyed, roads were swept away and stagnant, dirty water encouraged vast numbers of mosquitoes to breed.

The biggest impact was not from the high winds but from the flooding. Low pressure meant that the sea was no longer depressed by the atmosphere and so the sea level rose. As a result, the low-lying coastal areas of the Irrawaddy river were flooded.

The short-term effects were that people drowned and many were made homeless. In the longer term fields were destroyed, families were devastated and development was put back by years.

The response to Cyclone Nargis

As the scale of the disaster became clear, it also became clear that the military government of Myanmar was not doing as much as the rest of the world thought it could. Stories leaked out of aid being kept in the major cities and not spreading out to rural areas. Foreign aid workers were either not allowed in to help or were restricted in where they could go.

More than a week after the cyclone hit only one in ten of those affected had received some sort of aid. MEIDC governments locally accessed the government of Myanmar of making the situation even worse. This army banned volunteers, closed points on rivers stopped journalists from covering the disaster. For television, few reports were distributed to inform people that aid deliveries are only reaching children and others who do not need help. What lies behind these tactics is hard to say, but reports suggest that it is an attempt to preserve the prestige of Myanmar within its own boundaries and across the world.

THINK ABOUT IT

Much of the anger in the western world has been used to highlight previous human rights abuses in Myanmar and the lack of democracy in the country. This has meant that the rulers of Myanmar have been even slower to let foreigners in. Should the UK government do anything other than send in supplies to help?

ACTIVITIES

1. What were the physical factors that made Cyclone Nargis so destructive in Myanmar?
2. Why did so many people choose to live in such a potentially dangerous area as the Irrawaddy Delta?
3. What things would you do to make a disaster like Nargis less damaging?
4. How would you change the government?

PLENARY ACTIVITY

If you were in charge of defending Myanmar against future cyclones what would you prioritise? How would you go about putting them into action?
Disaster aid
- Set up relief camps to provide food, water and shelter in the immediate aftermath of the storm.

Promote individual responsibility
- Inform people about insurance against the possible impacts of the storm.
- Educate people so that they know what to do when a hurricane approaches. This might be through broadcasting or providing leaflets and holding meetings.
- Offer residents low-cost loans that must be spent on strengthening existing properties with storm shelters. Hurricane shelters can be built.
- Set up co-operative banks with low interest rates, so that when people want to rebuild their homes or businesses after the storm they can easily get loans to buy materials that they need.

Hazard-resistant design
- Build embankments or levées around settlements so that storm surges are less likely to flood coastal areas.
- Strengthen houses and roofs so that they are not damaged during the high winds.
- Build houses on stilts so that they are less likely to flood.
- Improve sanitation so that there is less danger of sewage leaking into drinking water.
- Build better roads so that evacuation can be more effective, and rescue and relief workers can reach affected areas more quickly.
- Strengthen and raise the banks of rivers so that the increased flow caused by the heavy rain and storm surges will not cause flooding.
- Build sea walls to protect densely populated areas near the coast.

Warning and forecasting
- Improve weather stations so that they can give early warning of storms.
- Get better at warning people and evacuating them from the danger area. This can be done through the use of satellites.
- Improve land use planning.
- Plant shelter belts of trees along the coast that will shield homes from the effects of the strong winds.
- Zone land use so that housing is not near the coast. Agricultural land can be allowed to flood.
- Replant and reinstate lost swamps along coastlines.

There are many different measures that can be introduced to reduce the impacts of cyclones; Figure 3.57 lists just some.

<table>
<thead>
<tr>
<th>Storm</th>
<th>Date</th>
<th>Windspeed</th>
<th>Death toll</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurricane Gustav (USA)</td>
<td>August 2008</td>
<td>241 kph</td>
<td>10</td>
<td>US $15 billion</td>
</tr>
<tr>
<td>Cyclone Sidr (Bangladesh)</td>
<td>November 2007</td>
<td>257 kph</td>
<td>3447</td>
<td>US $1.7 billion</td>
</tr>
</tbody>
</table>

Figure 3.57 Reducing the impact of cyclones.
**Drought**

**What causes droughts?**

A drought occurs when there is not enough rain to support people or crops. The cause of droughts is easily understood, but hard to prevent. Depending on the location, crop failures, famine, high food prices and deaths can occur. Unlike other forms of severe weather or natural disasters, droughts often develop slowly.

Different parts of the world have different climates so each country has its own definition of drought. Drought is a normal, recurrent feature of climate. It occurs almost everywhere, although its features vary from region to region. Defining drought is therefore difficult; it depends on differences in regions and needs. Drought in Libya is said to occur when rainfall is less than 180 mm, but in Bali, drought is considered to occur after a period of only 6 days without rain.

In the most general sense, drought originates from a reduction of precipitation over an extended period of time, resulting in a water shortage for some activity, group or environmental sector. Knowing the amount of precipitation in an area is not enough to predict whether drought will occur. It is necessary to consider the effective precipitation – the difference between the amount of rain that falls and the amount of evapotranspiration.

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**Figure 3.60** Factors of drought.

- **Economics**: Wealth of people coping with low rainfall, e.g. whether they can afford to build new reservoirs, wells, etc.
- **Social**: The number of people affected has an impact on the amount of water needed. Demand is greater in developed countries.
- **Politics**: War and civil war affect people's access to water. In developing countries it is easier to implement laws to control use of water.
- **Technology**: Levels of technology have an impact on the efficiency of water storage and new ways to supply water.
- **Environment**: Different types of rock allow water to be stored or run across the surface; different land uses affect runoff rates.
- **Use and users**: In an LEDC subsistence community people use less water, but only a small reduction in water supply can have devastating effects on the quality of life. Luxury users in an MEDC will not usually suffer life-threatening impacts during periods of drought. Use affects the sustainability of water supply.
How to create a stoneline

1. Work out which way water flows - mark out contours on the ground

2. To find contours - water finds own level - use plastic tube filled with water - attached to measuring post. When water levels are the same - found contour

3. Mark contour out on ground

4. Willing helpers - bring local people together and think of solutions - get everyone involved

5. Get large stones - place along the contours to form a low wall

6. Fill in wall with smaller stones to prevent soil being washed away
CASE STUDY Ethiopia in the Sahel - drought in an LEDC

Countries in tropical latitudes experience a distinct wet and dry season. If the rains fail to arrive, the resulting drought can be disastrous for crops, animals and people. The Sahel area of Africa is an area particularly prone to drought. It stretches in a broad band south of the Sahara Desert between latitudes 12°N and 19°S. Drought occurs in this area when the moist, rainy air at the Equator is prevented from moving north and reaching the countries of the Sahel. Higher sea temperatures are also thought to be partly responsible.

Ethiopia

The drought of 1984-85 in Ethiopia resulted in over a million people dying. This disaster led to the release of the song 'Do They Know It's Christmas?' and the founding of the Live Aid charity concert. Ethiopia continues to suffer from drought and suffered another major disaster in 2006.

June 2006: Rains fail again in Ethiopia

This year the rains, which begin in February, and the long rains stretching into June failed to supply enough water for the country's needs.

More aid needed

Most years, Ethiopia has to depend on some level of food aid as it barely produces enough to feed the whole population. The initial estimates were that 7.5 million people would need food aid, but the extent of the drought and therefore the food situation has meant that the numbers affected are rising. The country's prime minister has said that six million people are in need of immediate aid and that number could rise to 13 million if international donors do not help Ethiopia.

August 2006: Hendra virus in Ethiopia

Pasture and water are drying up and beehives have started to die off. Thousands of cattle are on the move - but there is no food in sight. All people can do is helplessly look on as their animals die on the road. Under temperatures of up to 50°C, the nomadic peoples trek hundreds of kilometres through the arid desert in search of water and grazing pastures. Those reports of cattle along the road between Dire Dawa and Djibouti, Zai River and Lakes Assal and Abbe are causing concern.

Disease

There are also increasing scares of an outbreak of cholera due to the huge number of corpses of dead animals in the Arusha river, the main water source for people in the area. aid agencies say that people who are already weak due to lack of food are especially vulnerable to diseases.

Agriculture

Farmers have ploughed three, twice and then a third time. Each time the crop has withered. The agricultural practices that provided the farmers well are now well and truly exhausted. All over the Ethiopian highlands, farmers have been divided and subdivided so often they are little more than scraps of land. Farmers cultivate dry plots, some of which are very steep.

RESEARCH LINK

Which other countries of the Sahel are experiencing drought this year? Make a list of the impacts of the drought. Use the Internet to research your answers.

ACtivities

1. What are the natural causes of drought in the Sahel region?
2. Using the map compare the areas of drought and rainfall.
3. Use the Fact file andgallery to make a bubble map of the causes and effects of drought in Ethiopia.

Pleral activity

Identify different people's perceptions of the landscape shown in the photographs in Figures 3.43 and 3.45 - as grazing land, as an area for agriculture, as an area receiving food aid.
CASE STUDY  Australia 2005–2006 – drought in an MEDC

GET STARTED

Eighty per cent of all agricultural production is exported from Australia. Use an atlas to find out what the products are in terms of crops and livestock. How might a drought affect each of the agricultural types you have mentioned?

KEY TERMS
El Niño – large climatic disturbances in the Warm current (offPeru) Pacific Ocean that occur every 3–7 years.

Fact file
The number of sheep in Australia fell by 6 million between 2004 and 2006.

RESEARCH LINK
Are droughts occurring more frequently and over larger areas in Australia? Use a web search to find out how many droughts the continent has suffered over the past 100 years. What might be the explanations for this?

Effects of the drought:
- crops failed, resulting in a loss of income for farmers
- many cattle and sheep died of starvation or of thirst, or had to be shot because they were suffering so much
- farmers sold their land and moved to the towns to find other work
- severe loss of vegetation due to the drought resulted in soil erosion
- farmers had to borrow large amounts to buy feed for their animals
- there were several large bushfires and dust storms during the drought
- water quality declined as water sources ran dry, leading to the formation of toxic algae.

ACTIVITIES
1 Which of the diagrams below (a or b) represents normal weather patterns for Australia, and which represents abnormal ones?
2 Look at Figure 3.62 and describe the areas of Australia most prone to drought. Using an atlas of population distribution in Australia, name three areas that are densely populated and three areas that are sparsely populated that suffer from drought.
3 Imagine you lived in the house shown in Figure 3.67. How would water conservation measures affect your family in a week?

Can Australia be drought-proof?

Figure 3.67 Drought regulations in Queensland, Australia. (Source: Rytonuck Marilla Pty Ltd, Australia)
The annual migration pattern of nomadic pastoralists is destroyed by advancing desert. Waterholes disappear.

Farmers attempt to grow crops in areas of low rainfall.

Isolated heavy rainstorms wash away soil exposed by overgrazing and overcropping.

Increased grazing of animals in drought areas leads to fewer roots to hold soil together.

Area of irrigated land increases.

Woodlands disappear as trees are cut down for fuel.

Cities grow due to rural–urban migration.

Figure 3.70 Causes of desertification.