

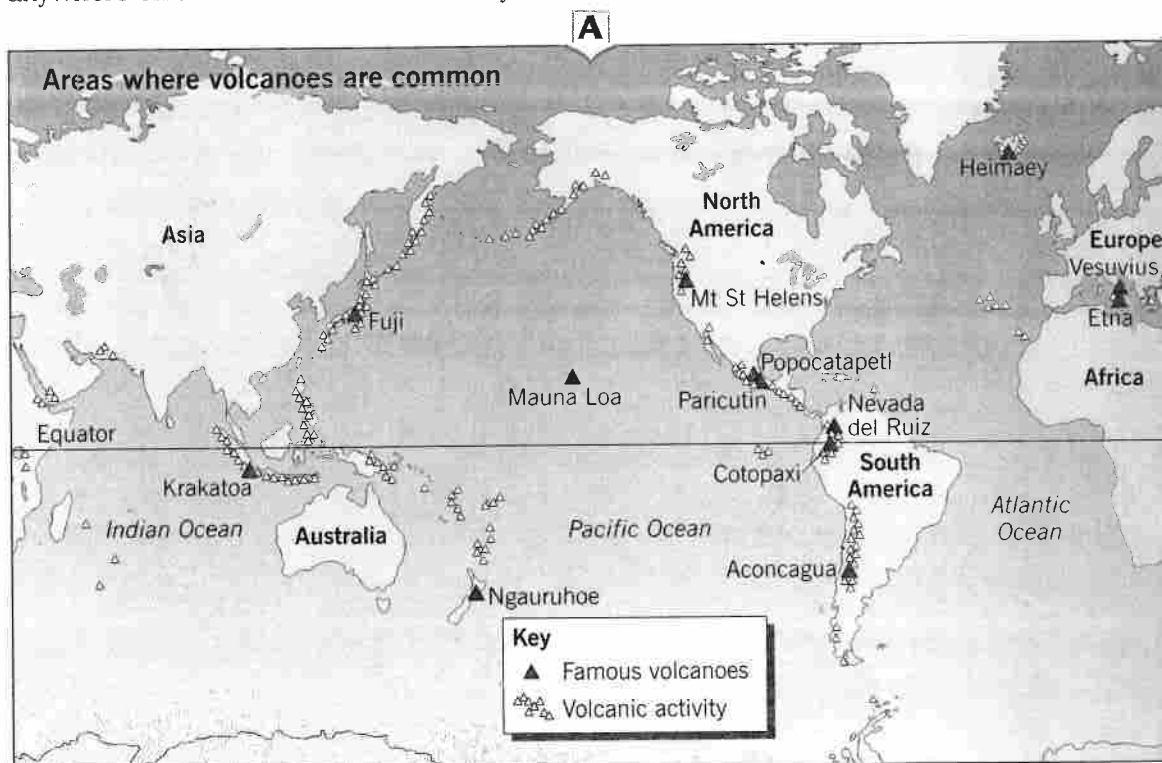
# Where do volcanoes and earthquakes happen?

There are thousands of **volcanoes** around the world. Some are extinct, some are dormant and some may be erupting even as you read this book. When they do erupt you can be sure that wherever they are, there will be danger and, probably, damage.

Scientists now know a lot about volcanoes but they still find it difficult to predict exactly where and when an eruption will actually happen. What we do know, however, is that volcanic eruptions do not occur just anywhere on the earth's surface but they

are confined to certain areas. Map A shows these areas.

Notice that most volcanoes occur in narrow belts or are grouped together in small clumps. One belt runs all the way round the edge of the Pacific Ocean and is called the **'Ring of Fire'**. Another belt runs through the islands of the Indian Ocean. There is also great volcanic activity on Iceland. Can you find the area in the Mediterranean Sea where the volcanoes of Italy are located?



## Activities

- 1 a Which four of the following describe where volcanoes may be found?
  - All over the world
  - In narrow belts
  - In Iceland
  - In Japan
  - In Central Asia
  - Along the west coast of North and South America
  - In Australia
- b Name two other places where volcanoes may be found.

- 2 Suggest reasons for the name of 'Ring of Fire'.
- 3 You may need an atlas for this question. Match each of the volcanoes named on map A with a country from the list in the box below. Some countries may be used more than once.

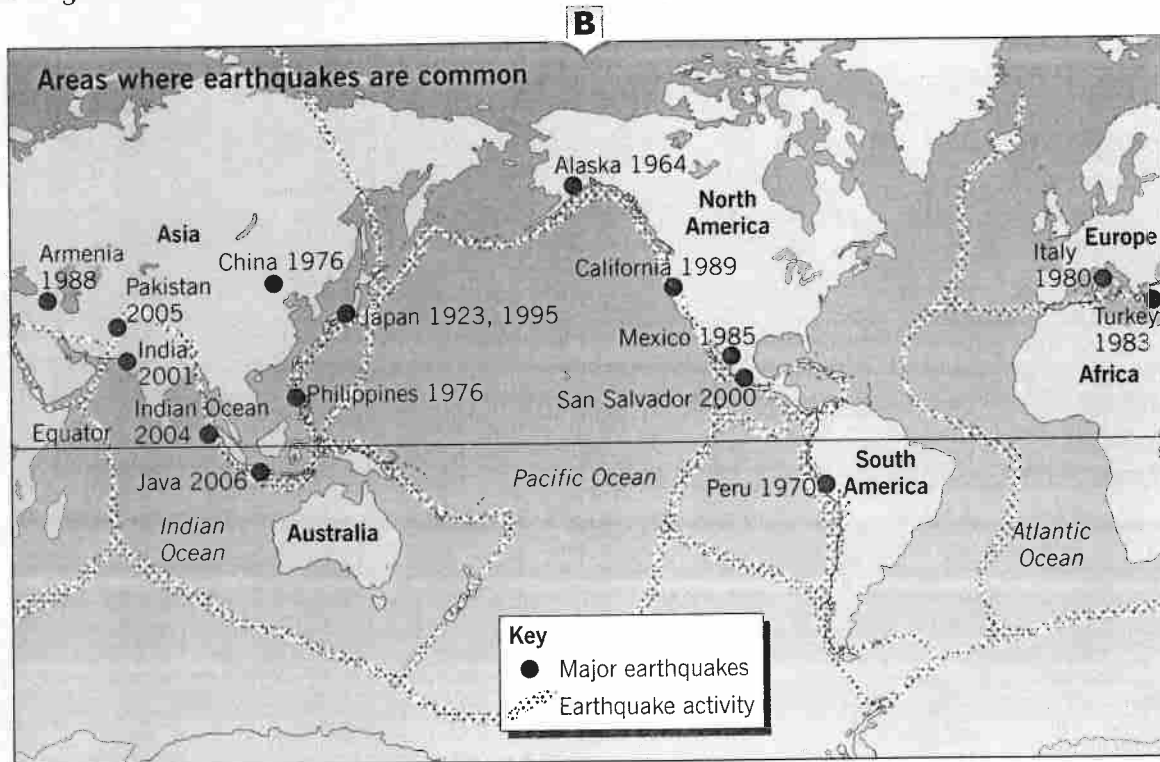
- New Zealand • Colombia • Japan
- Mexico • Italy • Argentina
- Indonesia • Iceland • Ecuador • USA

**Earthquakes** are happening all the time. Some are so weak that they can hardly be felt and instruments called **seismographs** are needed to detect them. Others, like the San Francisco earthquake, are so powerful that the shaking of the ground causes buildings to collapse and landslides to occur. The Indian Ocean earthquake of 2004 caused **tsunami** waves that killed more than 300,000 people.

Earthquakes can occur anywhere, but they are much more common in some places than in others. Map **B** shows where earthquakes regularly happen. Look carefully at their distribution. They are mostly arranged in long narrow belts. One belt goes down the middle of the Atlantic

Ocean. Another follows the west coast of North and South America and then goes all the way round the edge of the Pacific Ocean to New Zealand. Try to identify some other belts.

Now compare map **B**, showing earthquakes, with map **A**, showing volcanoes. Notice how similar they are. Look particularly at the 'Ring of Fire' and the Mediterranean countries. From studying maps like these, scientists have concluded that volcanoes and earthquakes often occur in the same places and are usually found in long narrow **zones of activity**. These areas can be the most dangerous places on earth.



- 4 Use the information on this page to describe where earthquakes happen.
- 5 Name five places where a scientist could study both volcanoes **and** earthquakes in the same area.
- 6 The eastern part of South America is an area largely without volcanoes and earthquakes. Name five other land areas where volcanic eruptions and earthquakes are uncommon.

### EXTRA

Use the internet to find out more about one of the volcanoes or earthquakes on map **A** or map **B**. Write a short project about it. Try to include:

- a map to show its location
- a description of the eruption or earthquake
- a list of damage it caused
- labelled drawings to show what happened.

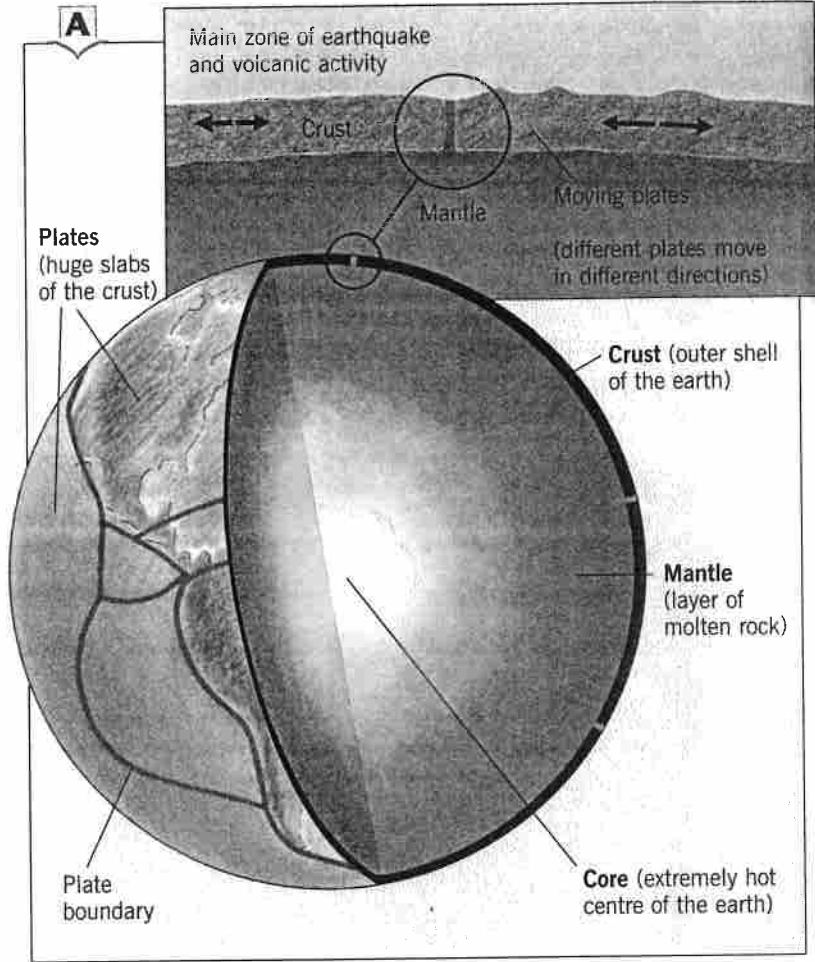
**Summary**

Most volcanoes and earthquakes are found in long narrow belts across the earth's surface. The main zones of activity lie along the west coast of the Americas and among islands of the Pacific and Indian Oceans.

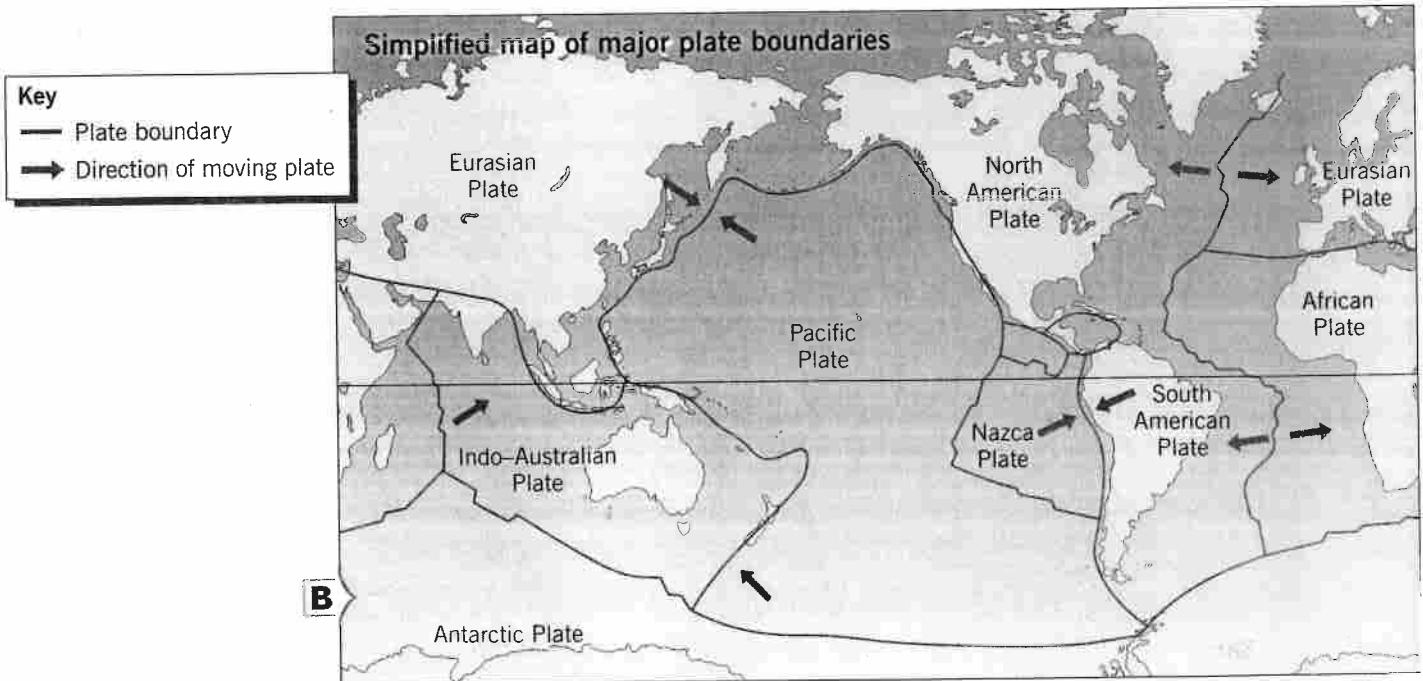
# How do volcanoes and earthquakes happen?

As you have seen on pages 28 and 29, volcanoes and earthquakes often occur in the same places and are usually found in long narrow belts. This gives a clue about how they happen.

The earth was formed 4,600 million years ago. Since then it has been slowly cooling down and a thin **crust** has formed round the outside. The crust is not all one piece but is broken into several enormous sections called **plates**. Some of the plates are as large as continents while others are much smaller. Underneath the crust the rock is so hot that it remains molten and can flow like treacle. The plates float on this layer and move about very, very slowly – just a few millimetres a year. In some places they move towards each other and in others they move apart or scrape alongside each other. The place where two plates meet is called a **plate boundary** (diagram A). The movement at these plate boundaries can cause earthquakes and volcanic eruptions to occur.



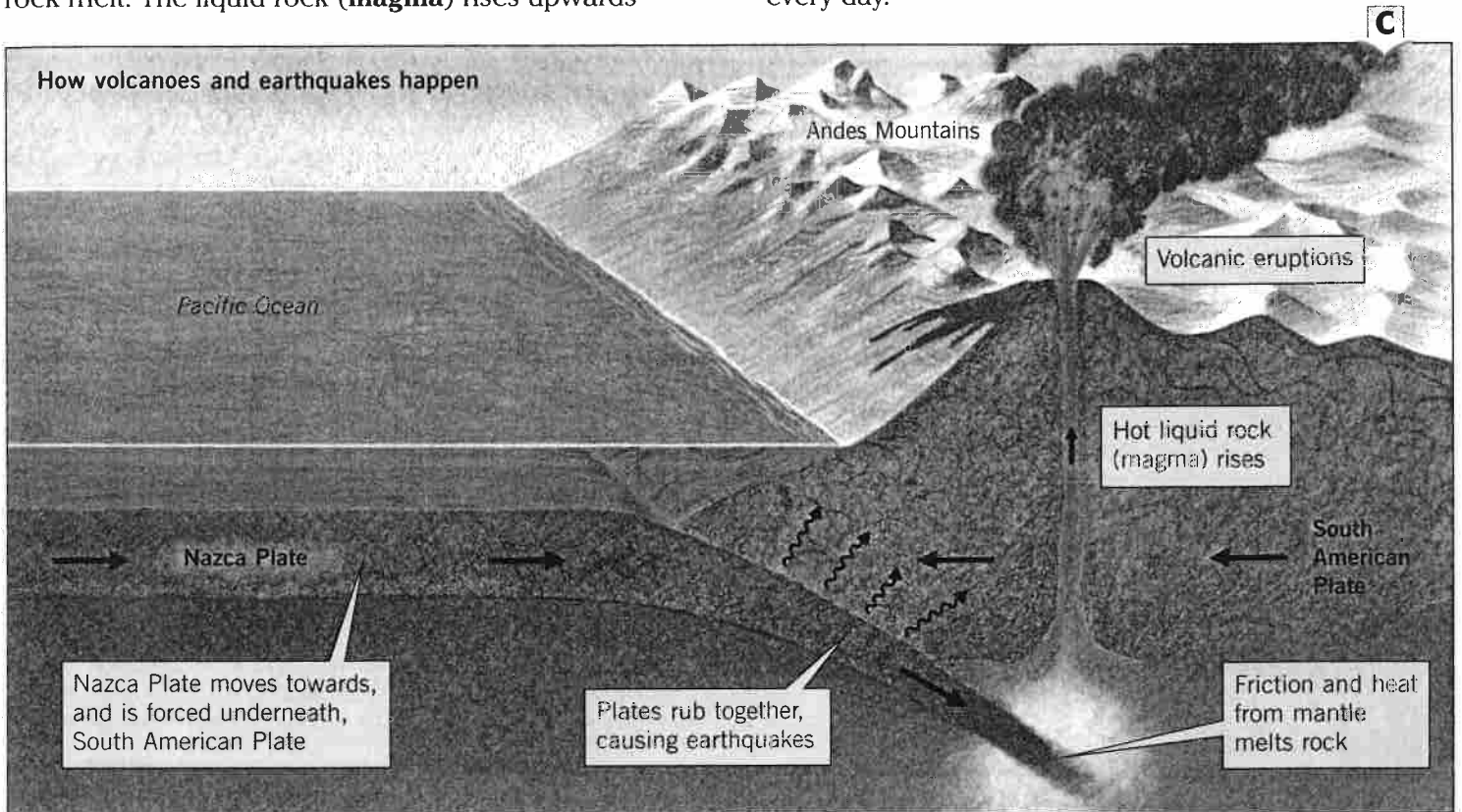
Look at map B which shows the major plate boundaries. Compare it with the volcanoes map on page 28 and the earthquakes map on page 29. Look particularly at the 'Ring of Fire' around the Pacific Ocean. You should be able to see that most of the volcanoes and earthquakes happen along the plate boundaries.



## 2 Volcanoes and earthquakes

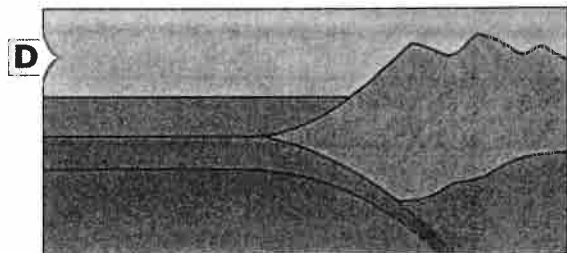
Diagram C shows what happens where plates move together. Here, on the west coast of South America, the Nazca Plate is being forced towards and underneath the South American Plate. As the plates move together the friction between them makes the rock melt. The liquid rock (**magma**) rises upwards

and erupts on the surface as a volcano. The movement of the plates scraping together also makes the ground shake and sets off earthquakes. South America has over a hundred volcanoes caused in this way and in some places earthquakes happen every day.



## Activities

- 1 Look carefully at map B.
  - a On which plate does Britain lie?
  - b Why does Britain have no active volcanoes or major earthquakes?
  - c Which two plates meet along the west coast of the USA?
  - d Why do earthquakes happen in San Francisco?
- 2 Sort the statements below into the correct order to show how volcanoes can happen at plate boundaries.
  - Molten rock rises
  - Friction melts the rock
  - Plates rub together
  - Volcanoes erupt on the surface
  - Plates move towards each other
- 3 How does the movement of plates cause earthquakes?
- 4 a Make a larger copy of cross-section D.
  - b Name the two plates, the Andes mountains and the Pacific Ocean.
  - c Draw arrows to show plate movements.
  - d Put a circle around the zone of activity where there is friction, earthquakes and melting of rock.
  - e Add a title.



## Summary

The earth's surface is made up of several plates that move about very slowly. Volcanoes and earthquakes are most likely to occur in areas where the plates meet.

## What are volcanoes?

Volcanoes are openings (**vents**) in the ground where **magma** (molten rock) from deep inside the earth forces its way to the surface. The magma may appear as flows of molten **lava**, as **volcanic bombs**, as fragments of rock or simply as **ash** and **dust**. Mountains that are made of these materials are called volcanoes. Look at diagram A. It shows the main features of a volcano and gives an idea of what one looks like inside.

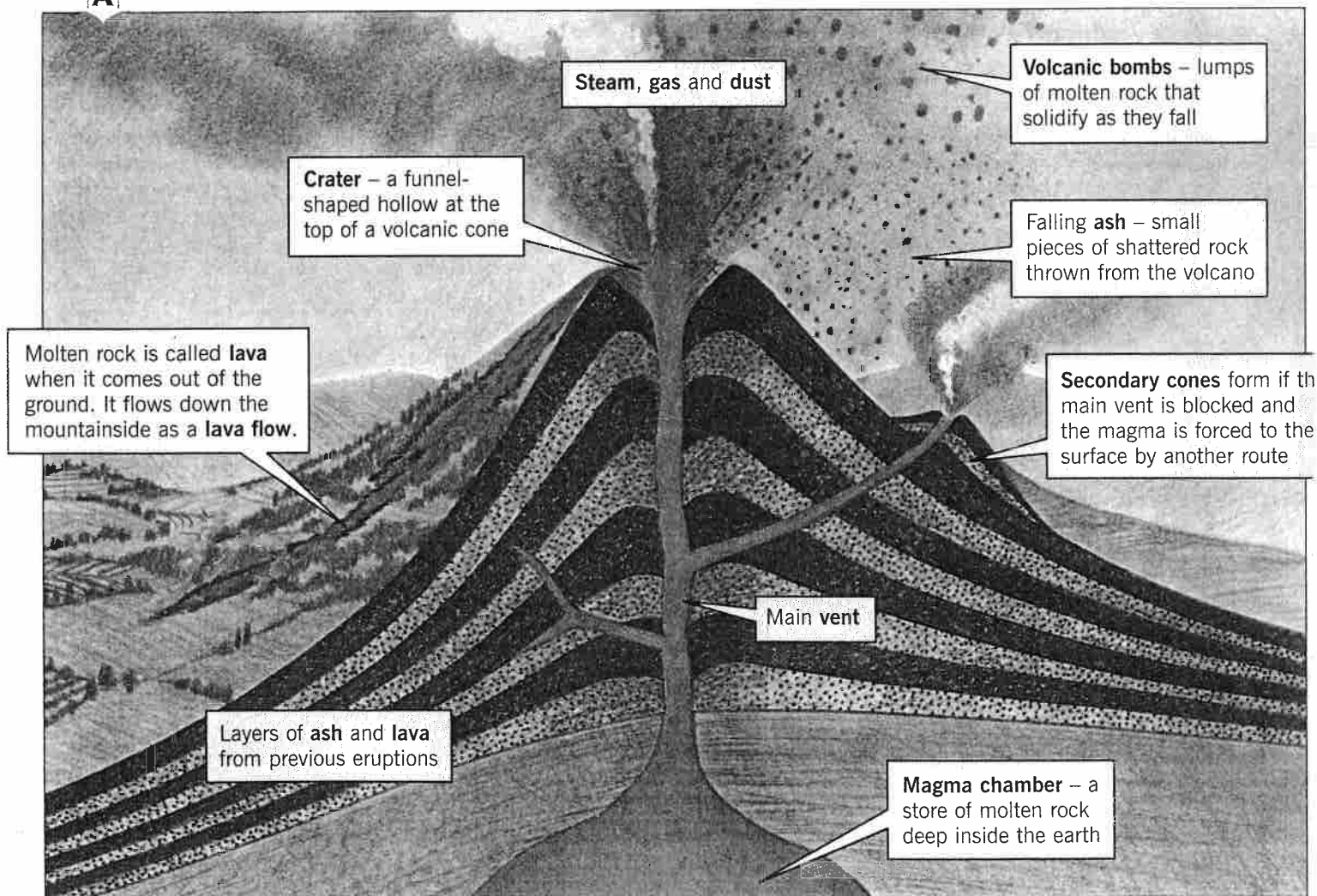
Volcanoes may be **active**, **dormant** or **extinct**.

- ◆ If a volcano has erupted recently and is likely to erupt again, it is described as active. There are over 700 active volcanoes around the world.

Mount Etna is an active volcano because it erupted as recently as 1971, 1983, 1992, 2000, 2002 and 2005, and is expected to erupt again in the near future.

- ◆ Volcanoes that have erupted in the past 2,000 years, but not recently, are said to be dormant or sleeping. These may be dangerous as it is difficult to predict when they are going to erupt again.
- ◆ Many volcanoes are unlikely ever to erupt again. They are said to be extinct because they are dead and their volcanic activity is finished. Britain's last volcanoes erupted over 50 million years ago and have mostly been worn away by erosion. The Edinburgh volcano in Scotland, and Snowdon in Wales, are examples of extinct volcanoes in Britain.

A

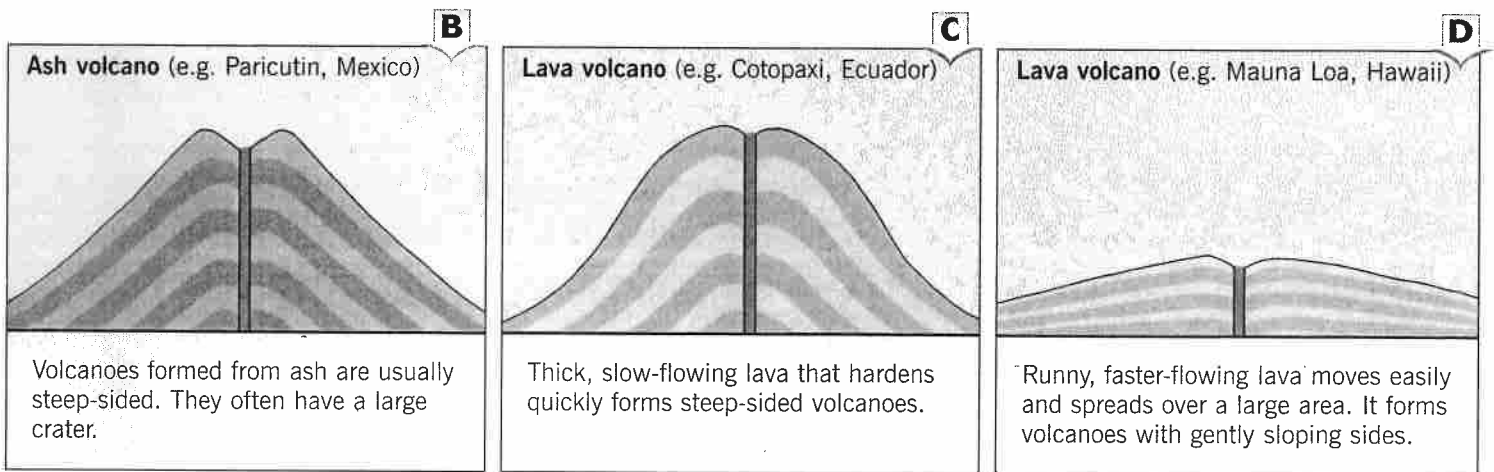


## 2 Volcanoes and earthquakes

When a volcano erupts, the magma from below the earth's surface rises up the vent to the volcano's crater. It then explodes into the air as ash, dust and volcanic bombs, or flows out as molten lava. Some eruptions are spectacular and take the form of huge and violent explosions. The greatest volcanic explosion of modern times happened when the Indonesian island of Krakatoa erupted in 1883. The noise from that was so loud that it could be heard over 4,700 km (3,000 miles) away in Australia – see map **A** on page 28.

Not all eruptions are like Krakatoa. Some can be quite gentle and fairly peaceful. Mauna Loa on Hawaii, for example, pours out a steady stream of liquid lava with only a small amount of explosive force and occasional danger to nearby settlements.

Most volcanoes are cone-shaped but the steepness of their slopes can vary considerably. This steepness depends mainly on the type of lava erupted from the vent. Some different types of volcano are shown in diagrams **B**, **C** and **D**.



## Activities

- 1 a** What are volcanoes?  
**b** What is the difference between active, dormant and extinct volcanoes?

- 2** Give the meaning of the words below. You could add sketches to some of them to make them clearer and more interesting.

magma   vent   crater   lava

volcanic bombs   volcanic cone

- 3** Make a simple sketch of photo **E** and label the following:

two craters   steam coming out of vent

volcanic cone   ash and lava

Give your sketch a title.

- 4** Make a large drawing of a volcano like the one in sketch **A**. Label the features shown in bold type. Underneath your sketch write a description to explain what happens when it erupts. Try to mention all the labelled features.

**E** Crater of Ngauruhoe, New Zealand



## Summary

Volcanoes are cone-shaped mountains made from magma that has come from deep below the ground.

## What happens when a volcano erupts?

When a volcano erupts it can cause serious problems. People are put in danger and their surroundings can be severely damaged. Problems like this are called **natural hazards**. Earthquakes, floods, drought and strong winds are also examples of natural hazards. In spite of the danger and possibility of great destruction, a lot of people often live in volcanic areas. This is because ash and lava turn into rich fertile soil which is good for farming. Good farming areas are attractive places to live.

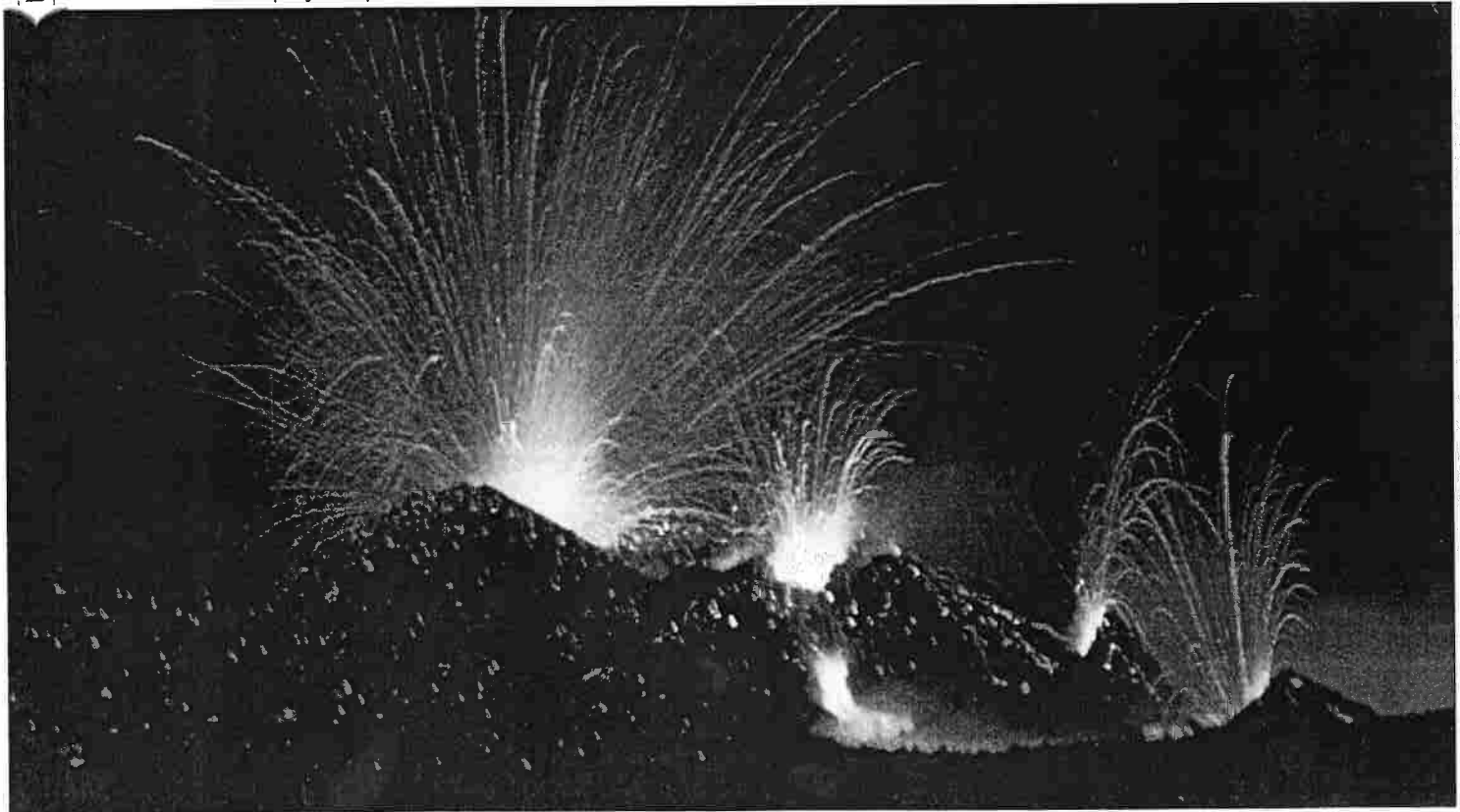
The largest and most active volcano in Europe is the 3,340 metre high Mount Etna. This volcano is located on the Italian island of Sicily and it continuously rumbles and steams. Several times in the last one hundred years Etna has had major eruptions, when masses of ash, volcanic bombs and lava have been blasted out of the cone, destroying the surrounding area. Over a million people live in the Mount Etna area and these eruptions have caused considerable problems for them.

Mount Etna erupted most recently in 1971, 1983, 1992, 2000, 2002 and 2005. In 1971 the eruption began with a



huge explosion that sounded like a jet aircraft taking off. This was followed by a spectacular fireworks display when red-hot ash was thrown hundreds of metres into the air and molten lava poured down the mountainside. In this eruption most of the ski slopes and cable car stations were destroyed and a research observatory near the summit was completely wiped out.

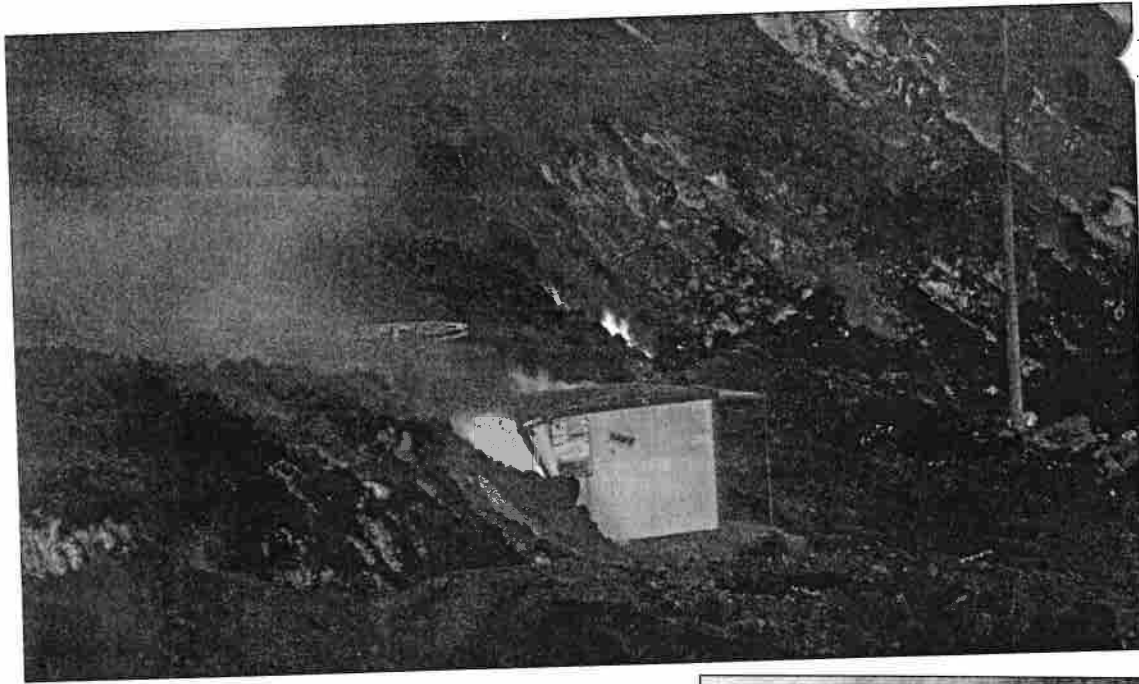
**B** The 'fireworks display' eruption of Mount Etna



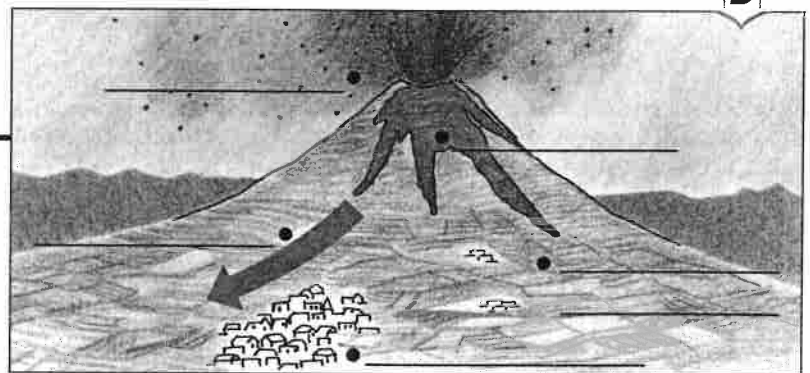
## 2 Volcanoes and earthquakes

The 1983 eruption began in March and continued for several months. Millions of tonnes of lava gushed out of the crater and engulfed a hotel, three restaurants, 25 houses and numerous orange groves and vineyards. The lava flowed at an average speed of 15 km per hour

(about the speed you ride a bicycle) and at one time threatened to bury several small villages in its path. Eventually a diversion was made and after a series of controlled explosions, the lava was diverted and the villages saved.



**C** Damage caused by the lava flows of the 1983 eruption of Mount Etna



### Activities

- ❖ **1** Why do volcanic areas often have a lot of people living in them?
- ❖ **2** **a** What is meant by the term 'natural hazard'?  
**b** Give four examples of natural hazards.
- ❖ **3** Describe what happens when Mount Etna erupts by sorting the boxes below into the correct order. Link your boxes with arrows and add a title. You might like to make a simple drawing for each box to make your description clearer and more interesting.

Lava pours down the mountainside

Buildings and property damaged

Rescue service goes into action

Volcano gently rumbles and steams

Loud explosion as volcano erupts

Ash, bombs and lava blasted out of volcano

- ❖ **4** **a** Make a simple copy of sketch **D** and put the following labels in the correct places.

lava flows

threatened settlement

diversion channel

ash and bombs

vineyards and orange groves

- b** Underneath your sketch list eight problems caused by Mount Etna erupting.

### Summary

When volcanoes like Mount Etna erupt they may bring danger to people and cause severe damage to property and the surroundings. Disasters caused by great forces such as volcanic eruptions, earthquakes, floods and strong winds are called natural hazards.



## What happens in an earthquake?

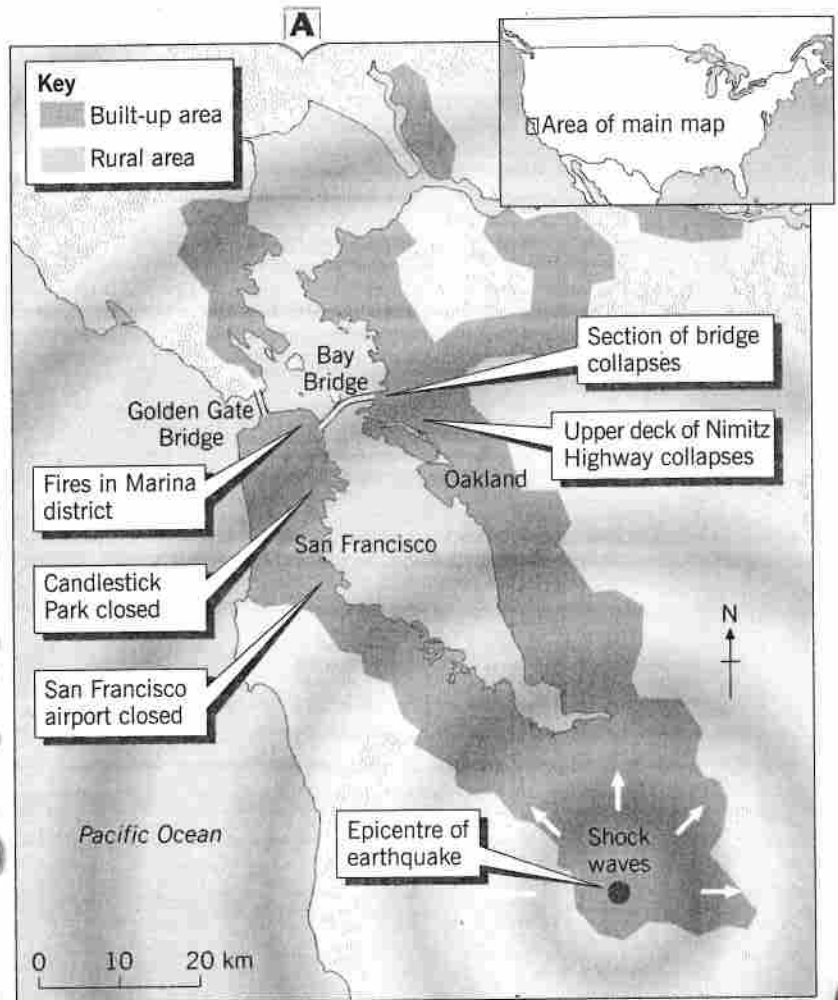
On Tuesday 17 October 1989 an **earthquake** hit the Californian city of San Francisco. These two pages explain through photos and newspaper articles what happened on that day.

B

### Quake hits 'Frisco'

At least 63 people were killed and over 3,000 were injured when an earthquake struck San Francisco at 5.04 p.m. yesterday. It ripped 10ft cracks in roads and a packed highway collapsed, crushing 253 motorists. Rescue workers struggled to free people from damaged buildings while fires roared throughout the city. More than a million homes were plunged into darkness and over 13,000 people were made homeless. Eyewitnesses said they heard a low rumbling noise before the quake hit. Everything then began to shake and buildings started to fall apart. Estimates of the damage already stand at \$7 billion. President Bush has promised immediate aid.

Wednesday 18 October, *San Francisco Herald*



C

### 'The whole world was shaking'

At San Francisco's City Hall, terrified staff dived under desks as pieces of the ceiling and walls came down. Across the street in the health department a giant gusher of water shot through the second floor.

Near the tourist area of Fisherman's Wharf an entire four-storey apartment block collapsed. A woman from the third floor said, 'It seemed like the whole world was shaking. I ran to the stairs to escape but they had gone. There was just a hole. I had to use the fire escape.' Others were not so lucky. They were trapped and couldn't get out.

Fires were inevitable. In one of the worst, a broken gas main exploded turning an entire block in the Marina district into a raging inferno. Firemen were unable to control the blaze which roared on through the night.

Thursday 19 October, *Daily Mail*



D

# Big shake wrecks road



An estimated 200 people were killed when a mile of two-tier road known as the Nimitz Highway collapsed. The road was built to be earthquake proof but the 'big shake' was too much for it. A huge section collapsed onto the road below, squashing hundreds of cars into a space that in places was just 12 inches high.

Further along the highway on the Bay Bridge, more motorists were killed when part of the bridge collapsed. A woman driver on the bridge at the time said, 'The whole structure wobbled and a great gap appeared in the roadway. Cars skidded out of control and some toppled over the edge.'

At Candlestick Park 60,000 baseball fans were packed into the stadium for the game between the Giants and the Athletics. The game had just begun when the earth began to shake and violent tremors ran through the stadium. Cracks opened up in the concrete stands and ripples over a foot high ran right across the park.

Several people were hit by chunks of falling metal and concrete but no-one was killed.

Thursday 19 October, *The Californian*

## Activities

1 Complete an earthquake Fact File using these headings.

Fact File	
Place _____	
Date _____	Injured _____
Time _____	Homeless _____
Dead _____	Damage cost _____

2 Look at the headlines below about the San Francisco earthquake. Write a newsflash to be read out on television giving news about the earthquake. Write about 40 words on each of any four of the headlines given below.

- F** Baseball blitzed      Many trapped
- Buildings toppled      Fires rage
- Bridge collapses      Highway squashed

## EXTRA

Below is a list of problems that faced the authorities after the earthquake. Which four do you consider to be the most urgent? Give reasons for your choice.

- Provide new homes for people
- Search for missing people
- Supply medicine
- Rescue stranded people
- Evacuate people in danger
- Supply food
- Supply drinking water

## Summary

Earthquakes make the ground shake and may cause buildings and other structures to collapse. Some earthquakes are violent and may cause severe hazards for people.

## What happened in the Indian earthquake?

**Millions panic as huge earthquake rocks India**

**No electricity, no phone, no water. Just a pile of rubble and a town full of bodies...**

**Death toll expected to reach 30,000**

At 8.50 am on Friday 26 January 2001, an earthquake struck the heavily populated state of Gujarat in western India. The 'quake measured 7.9 on the Richter scale and sent tremors thousands of kilometres across the continent. They were felt as far away as Nepal and Bangladesh. It was the most powerful earthquake to hit India since 1950 when 1,538 people were killed in Assam.

The 'quake lasted just 45 seconds but caused massive damage. The city of Bhuj, near the epicentre, was worst hit. More than half of the buildings collapsed and most of the town was reduced to piles of rubble. A survivor at the town's Prince Hotel said, 'The whole building began swaying from side to side and everyone started screaming. We ran into the street and watched the building crash

down around us'. Elsewhere, whole towns and villages were flattened and electricity and water supplies cut off. Many roads were damaged and closed to traffic.

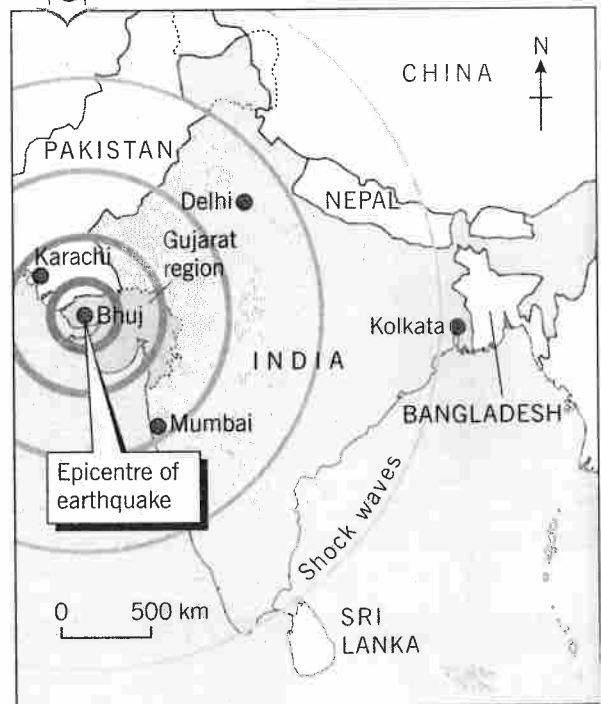
Most deaths and injuries were caused by building collapse. Rescuers used their bare hands to dig for relatives trapped in the rubble, usually with little success. Many children were killed when at school, whilst a group of 350, taking part in a Republic Day march, were buried when a wall collapsed. Over a million people have been made homeless and are without food or shelter. They face disease and starvation unless international help can save them.

Adapted from a national newspaper article,  
Monday 29 January 2001

**B** Rescuers dig out survivors with their bare hands



**C** Location of earthquake

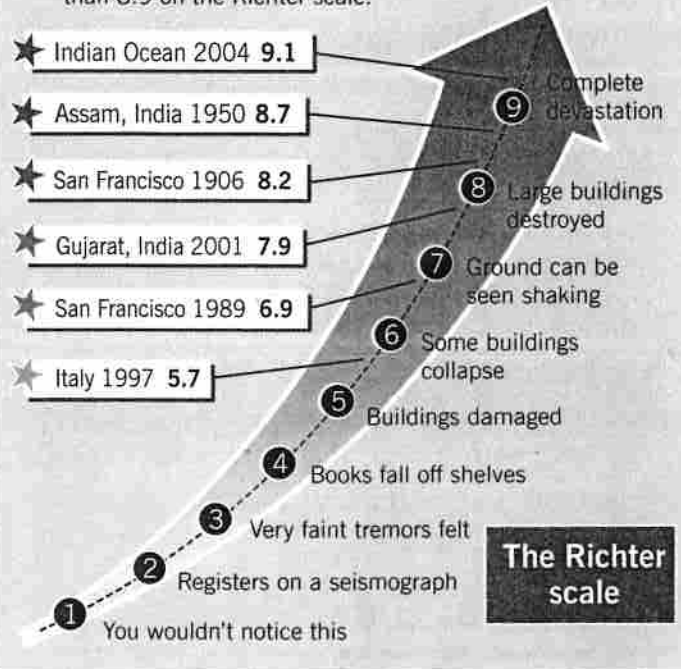


**D** Earthquake damage



**E** Measuring earthquakes

- The strength of an earthquake is usually measured on the **Richter scale**.
- Each level on the scale is ten times greater than the one below it. This means that an earthquake with a score of 7 is ten times more powerful than one with a score of 6.
- Most serious earthquakes are in the range of 5 to 9.
- Until 2004, no earthquake had ever measured more than 8.9 on the Richter scale.



**Activities**

- 1** a What is the Richter scale?  
 b Approximately how many times more powerful than the 1989 San Francisco earthquake was:  
 • the Gujarat earthquake  
 • the Assam earthquake?

- 2** Write a newspaper report on the Gujarat earthquake using the headings below.

**Gujarat earthquake report**

a What happened?  
 b Where did it happen?  
 c When did it happen?  
 d What damage was done?  
 e What were the effects on the people of the area?

- 3** Shahida Ali was trapped in the ruins of her school for 36 hours before rescue. Describe her ordeal. Try to include the words in the box.

shaking • crashing • screaming  
 • darkness • silence • pain  
 • frightened • crying • rescuers  
 digging • safety • cheering



**G** Shahida Ali survived the earthquake

**Summary**

Earthquakes are a major natural hazard and usually occur without warning. They can cause considerable damage and loss of life.

## How can the earthquake danger be reduced?

Many towns and cities in California have been built in the active earthquake zone along the San Andreas Fault. Aware of the dangers caused by earthquakes, the state has adopted a 'Three Ps' policy of **Predict**, **Protect** and **Prepare**, to try to reduce the worst effects of this natural hazard.

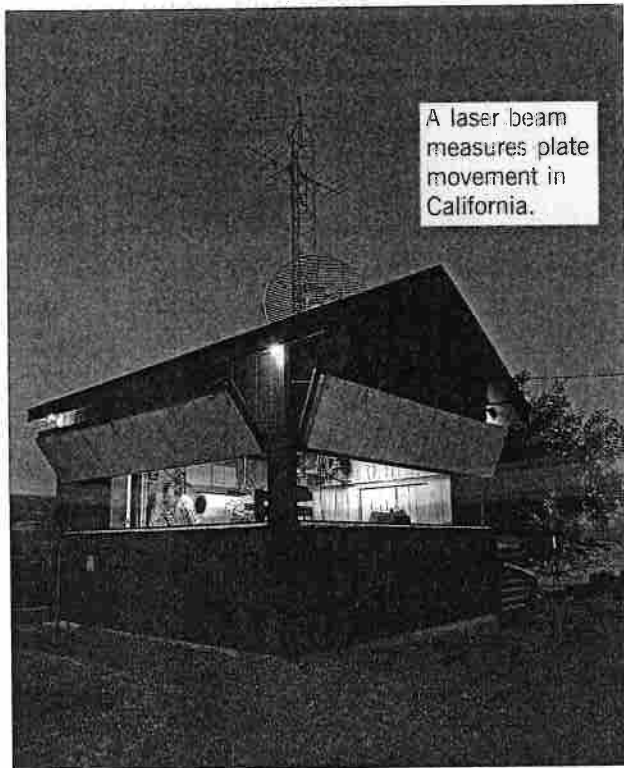
The accurate **prediction** of where and when an earthquake may happen is very difficult. Most earthquakes occur close to plate boundaries and scientists set up sensitive instruments in these areas to

monitor changes in the earth. Figure A lists some of the warning signs that help the scientists forecast where and when an earthquake might strike.

Most loss of life and damage to property in an earthquake is due to the collapse of buildings. The second part of the 'Three Ps' policy is to design and build structures that are safe and provide **protection** rather than cause danger in an earthquake. San Francisco's TransAmerican Pyramid, shown below, is an example of an earthquake-proof building.

**A**

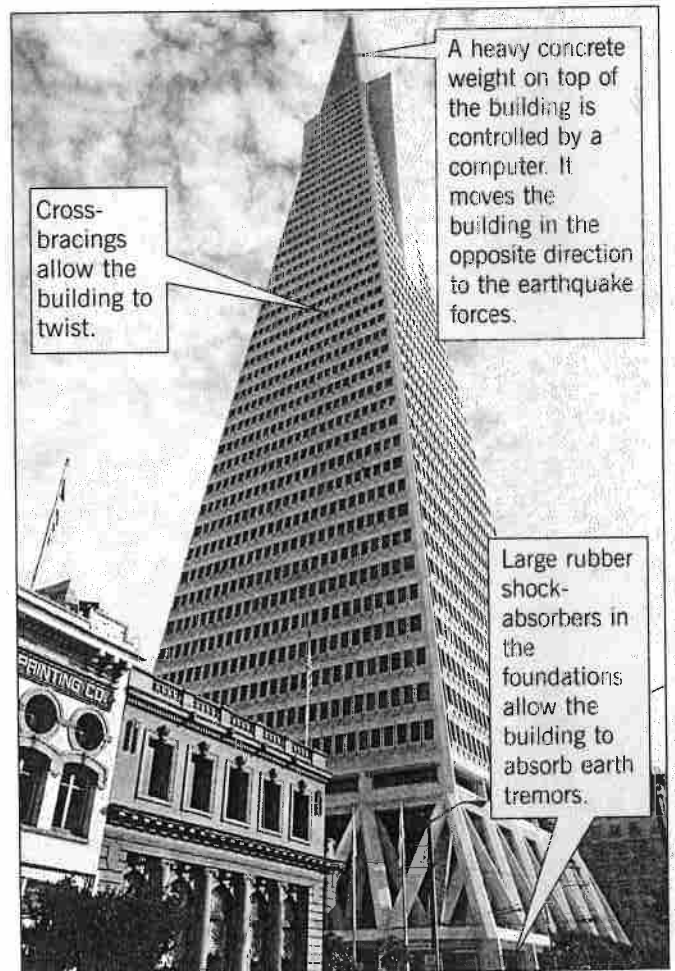
**Predict**



- 1 Earthquakes are most likely after long periods without any plate movement.
- 2 Just before a 'quake, small cracks develop in the rock.
  - The cracks cause the rock to swell and bulge.
  - Radon gas seeps out and can be measured as it bubbles to the surface.
  - The cracks fill with water and cause nearby water levels to change.
- 3 There will be many small foreshocks before the main 'quake. These can be measured with a **seismograph**.
- 4 Animals often act strangely. Snakes and rats crawl out of their holes and dogs howl.

**B**

**Protect**



- 1 All new buildings must comply with strict earthquake planning regulations.
- 2 Building regulations must be adhered to and frequent safety checks carried out.
- 3 Existing buildings, roads and bridges should be strengthened.

Good **preparation** and planning can help limit the worst effects of an earthquake. This should involve local authorities and emergency services as well as people living in the area.

Most places that are in danger areas have an emergency disaster plan which is usually in three parts. The first prepares the area for the disaster. The second tries to save lives and look after the people worst affected. The third aims to bring the area back to normal as quickly as possible.

In some parts of California, schoolchildren practise earthquake drills as part of their lessons. At the sound of a bell everyone must shelter under desks and then move quickly outside to be counted.

**C**

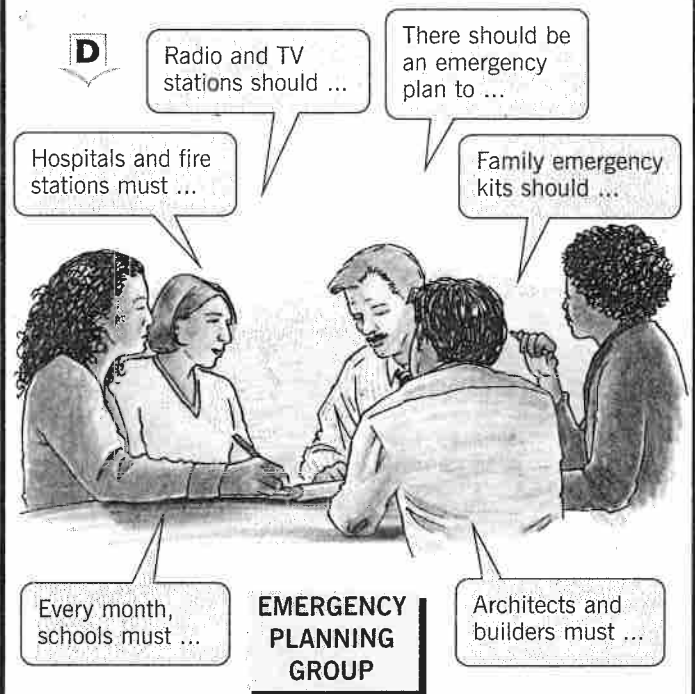
**Prepare**



- 1 Prepare disaster plans and carry out regular practices.
- 2 Train emergency services such as police, fire and ambulance crews.
- 3 Organise and prepare hospitals and evacuation centres in safe areas.
- 4 Educate people on what to expect and what will happen – turning off the gas supply, for example.
- 5 Organise emergency supplies of water, food and power in advance.
- 6 Set up an efficient earthquake warning and information system.

## Activities

- 1 It is not easy to predict an earthquake.
  - a What does 'predict' mean?
  - b Draw a star diagram to show four signs that suggest an earthquake may be about to happen.
  
- 2 Write out the sentence beginnings in drawing **D** and complete them with the correct endings from the following list:
  - ... follow the rules for safe buildings.
  - ... practise what to do in an earthquake.
  - ... include food, clothing, a radio and torch.
  - ... not be built in earthquake zones.
  - ... be prepared to give out earthquake advice.
  - ... help people who get injured.



- 3
  - a List the different ways that could be used to inform people about earthquakes.
  - b Draw a poster for your classroom wall to show exactly what should be done in an earthquake. Add drawings to make it clearer and more interesting.

## Summary

It is impossible to prevent earthquakes from happening. A policy of prediction, protection and preparation can help save lives and reduce damage to property.

## Two earthquakes compared

Despite the best preparations and well-practised emergency plans, earthquakes still kill people. This is mainly because it is impossible to predict exactly where or when an earthquake will strike, and how powerful it will be. For example, scientists are sure that certain areas of California will have more earthquakes, but despite all their efforts they still cannot say when.

However, as we have seen on pages 40 and 41, there are many other ways of limiting the worst effects of earthquakes. The San Francisco 'quake of 1989 was very powerful yet there were few deaths and the only buildings to collapse were those that had been built on unstable, reclaimed land. San Francisco's 'Three Ps' approach of Predict, Protect and Prepare had largely worked. But then California is one of the world's most wealthy regions and has the resources

and huge sums of money that a successful disaster plan requires.

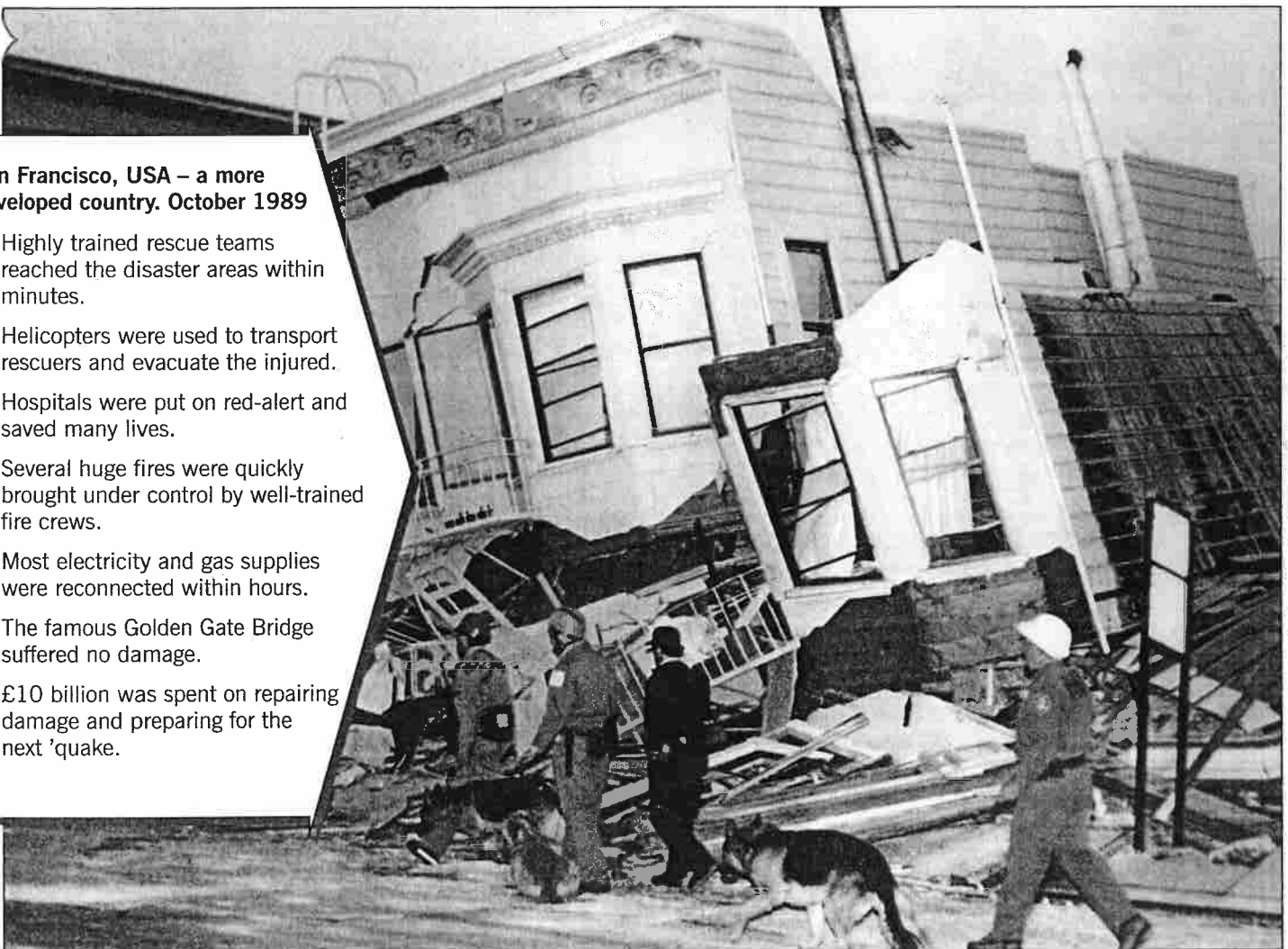
Sadly, many countries in earthquake zones are not so fortunate and are just too poor to protect themselves against natural disasters such as this. Some have no disaster plans at all whilst others are unable to enforce building safety codes or provide adequate resources and training for their emergency services.

In the Indian earthquake of 2001, for example, thousands of people died as poorly constructed buildings collapsed and emergency services were unable to cope with the disaster. Limited medical facilities and poor transport worsened the problem. The Indian government was seriously short of money, and had to ask for £1 billion of international aid to support the rescue effort.

A

### San Francisco, USA – a more developed country. October 1989

- Highly trained rescue teams reached the disaster areas within minutes.
- Helicopters were used to transport rescuers and evacuate the injured.
- Hospitals were put on red-alert and saved many lives.
- Several huge fires were quickly brought under control by well-trained fire crews.
- Most electricity and gas supplies were reconnected within hours.
- The famous Golden Gate Bridge suffered no damage.
- £10 billion was spent on repairing damage and preparing for the next 'quake.



# Activities

1 Why is it not possible to prevent all damage and loss of life in an earthquake?

- 2 a Make a larger copy of table B.  
 b Assess the success of each country's earthquake preparations by writing *Good* or *Bad* in the first column.  
 c Give a reason for your choice in the second column.

3 Explain why earthquakes in poorer, **less developed** countries usually do more damage than similar earthquakes in richer, **more developed** countries.

Use these headings:

- Prediction
- Protection
- Preparation.

## Summary

Poor countries, like India, find it very difficult to cope with natural hazards such as earthquakes. The effects of these disasters are therefore a lot worse than they would be for a rich country.

B	San Francisco, USA		Gujarat, India	
	Good/Bad	Reason	Good/Bad	Reason
Effectiveness of rescue teams	B	Delayed arrival	B	poorly equipped
Availability of transport	G	toilet and survival	B	collapsed bridges
Provision of medical facilities	B	limited	B	unavailable
Strength and quality of buildings	B	Buildings	B	poorly constructed
Availability of money	B	Rich countries	B	poorly equipped
Provision of aftercare	B	limited	B	poorly equipped

C

### Gujarat, India – a less developed country. January 2001

- Badly designed and poorly built houses collapsed, crushing people inside.
- Emergency electricity supplies and telephone links failed to work.
- Local rescue workers were poorly prepared and arrived too late to save many lives.
- Collapsed bridges and blocked roads hindered rescue teams.
- Many people died of their injuries due to limited medical facilities.
- Lack of food and unhealthy living conditions caused further deaths by starvation and disease.
- Over a million homeless people had no shelter, warm clothing or food.

