THE RESTLESS EARTH

If you could slice open the Earth like some giant apple, you would find several layers (fig.148).

As we stand on its surface, we think of the Earth as a solid ball of immovable cold rock. But deep beneath our feet, the Earth is neither solid nor cold ! One kilometre down it is 30°C warmer than at the surface. At the **core** of the Earth, it is white-hot as the temperatures reach 4,500°C. The Earth's core is a solid ball, 2,500 kilometres across.

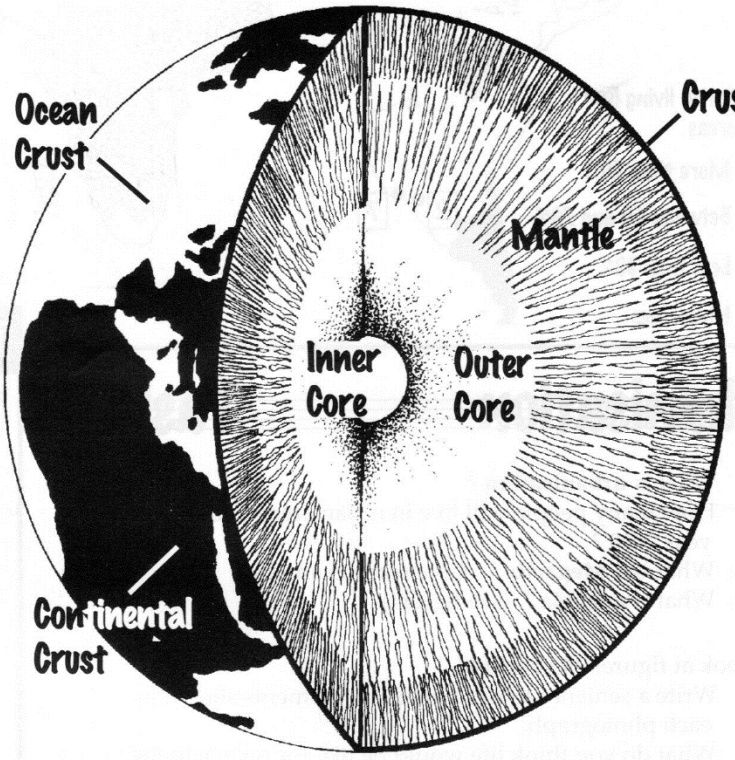
The **mantle** rocks are hot and semi-molten. Giant swirling, heat currents (or **convection currents)** are found in the mantle rocks. Above, lies the Earth's thin outer skin or **crust**. The crust is broken into massive chunks known as **plates** which slowly move about because of the movement of the convection currents in the mantle.

When rocks from the mantle break through the crust, volcanoes form (fig.149). Earthquakes take place when the crustal plates move. Volcanic eruptions and earth-quakes cause the deaths of people and wildlife and the destruction of property on a giant scale (figs.150-151).

Inside the Earth

Fig.148

The Earth is not perfectly round - it is slightly flattened the Poles. The distance around the Equator is 40,075 kilometres. The distance through the core is 12,755 kilometres.



The Crust has two main parts -

Continental Crust is old and solid. Up to 75 km thick , granite-type rocks form much of the continents

Ocean Crust is young and thin (5-10 km thick). It is made of heavy rock called Basalt.

The inside of the Earth has three parts -

The Mantle is made of semi-molten, hot rocks called Magma.

The Outer Core is made of red-hot , molten metals.

The Inner Core is solid and made of white-hot nickel and iron.

Restless Earth Tasks

1 Make a simple copy of figure **148**. Give your diagram a title and copy the **key**. Copy all the labels and then shade in your copy.

2 i. Write a sentence to explain the following terms - **Crust, Mantle, Outer Core, Inner Core, Plate**

ii. What is the difference between the following -
   a. **Ocean** and **Continental Crust**
   b. **Crust** and **Mantle** ?

3 Why is it hotter nearer to the Core than on the Earth's surface ?

4 Look at figures **149, 150** and **151**.

i. Which photograph shows -
   a. Red-hot lava erupting under the sea and spewing on to the surface ?
   b. The effects of a massive earthquake ?
   c. A volcano erupting white-hot lava, ash and gas everywhere ?

ii. Choose one of the photographs and write a report on the **problems** that might arise from the what is shown.

iii. Are there any **advantages** in eruptions and earthquakes ? Give your reasons.

5 i. Can you explain why volcanoes erupt and why earthquakes happen ?

ii. Make a copy of the **summary** from page **81**.

Fig.149 White-hot lava pours down Mount Etna as it erupts

Fig.150 Undersea eruptions spew lava and make new land on the crust of the Earth.

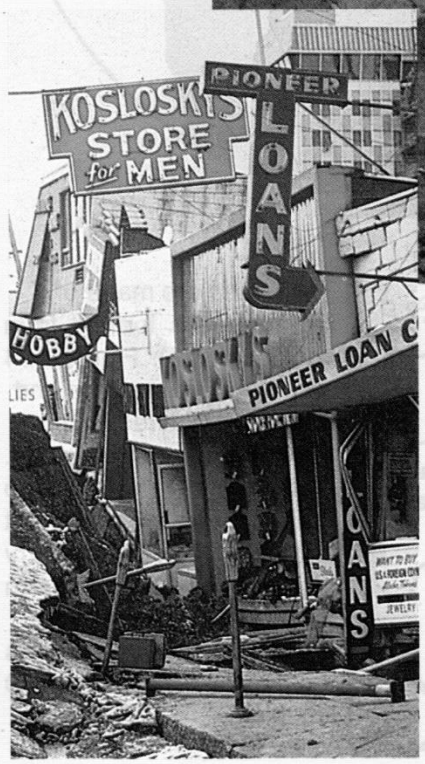


Fig.151 Buildings and roads destroyed by a massive earthquake.

SUMMARY

The surface of the Earth is covered by land and sea. The solid outer layer is called the Crust. Inside the Earth there are three layers - the Mantle, the inner and outer Cores. Death and destruction can be caused when volcanoes erupt or when the crust moves and earthquakes occur.

Restless Earth

1. i. Write the following labels in the correct places on the diagram opposite -

Ocean Crust **Mantle**
Outer Core **Crust**
Continental Crust
Inner Core

ii. Finish the **key** by filling in the missing information about each of the layers of the Earth.

2. How do we know that the Earth is not a perfect sphere ?

_____

_____

_____

3. What happens when molten rocks from the mantle break through the crust ?

_____

_____

4. When do **earthquakes** happen ?

_____

_____

5. What is the temperature of the rocks at the Earth's **Core** ?

_____

6. Why are the rocks of the Core so hot ?

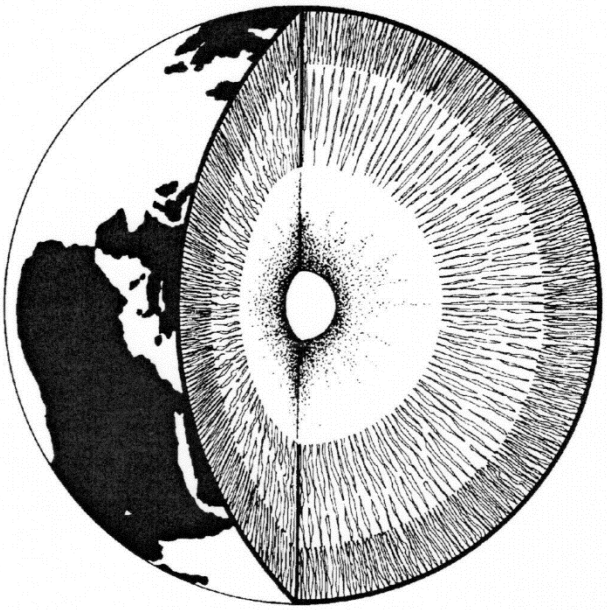
_____

_____

7. What is the molten rock of the **mantle** called ?

_____

INSIDE THE EARTH



KEY

The Earth's Crust has two main parts :-

Continental Crust

Ocean Crust

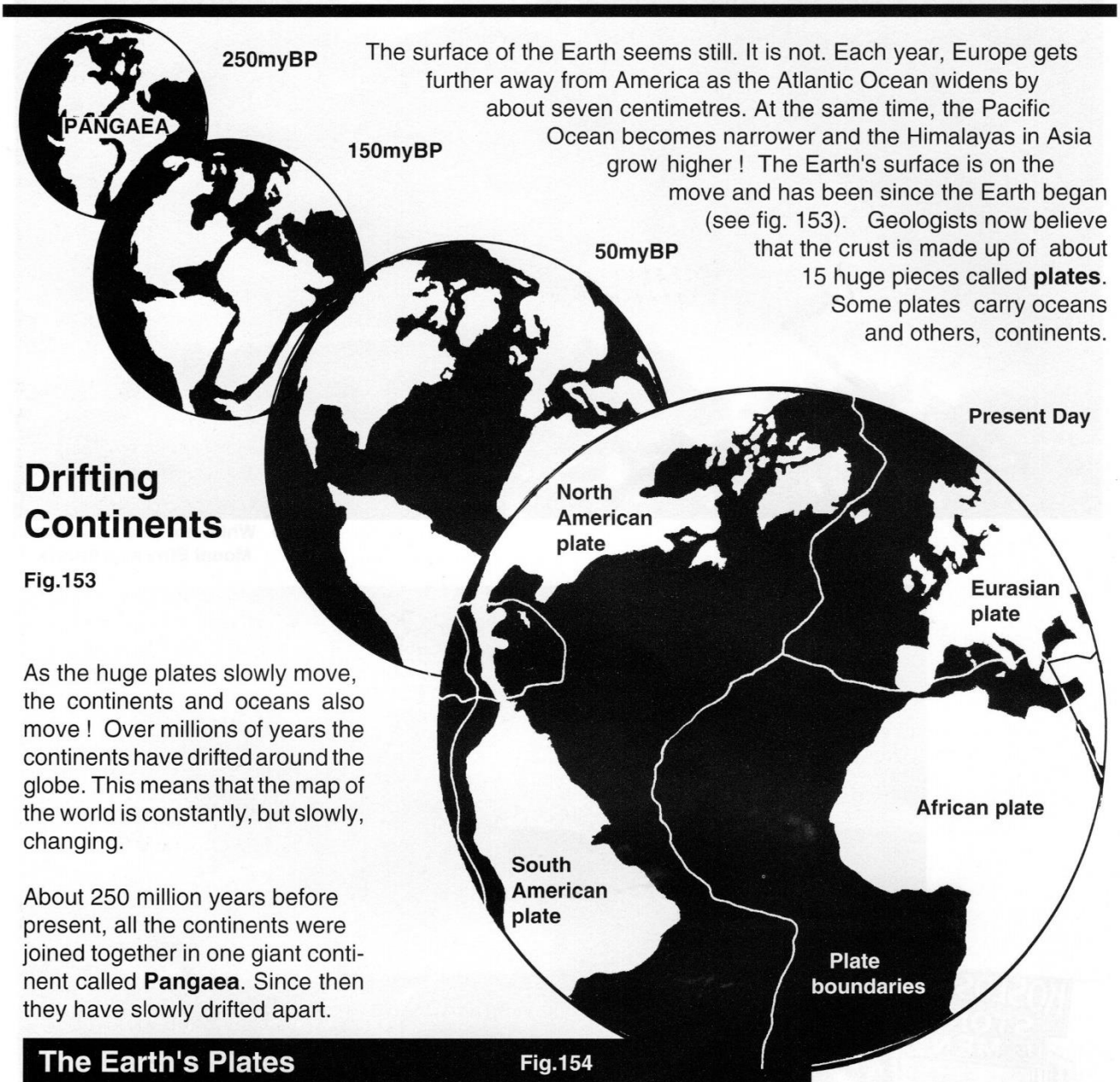
The Inside of the Earth has three parts :-

The Mantle

The Outer Core

The Inner Core

DRIFTING CONTINENTS



Drifting Continents

Fig.153

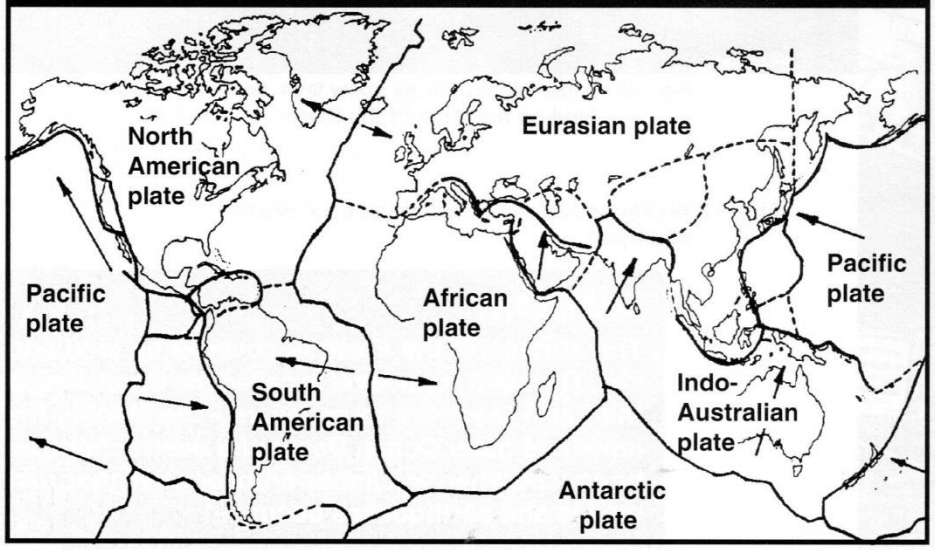
The surface of the Earth seems still. It is not. Each year, Europe gets further away from America as the Atlantic Ocean widens by about seven centimetres. At the same time, the Pacific Ocean becomes narrower and the Himalayas in Asia grow higher ! The Earth's surface is on the move and has been since the Earth began (see fig. 153). Geologists now believe that the crust is made up of about 15 huge pieces called **plates**. Some plates carry oceans and others, continents.

As the huge plates slowly move, the continents and oceans also move ! Over millions of years the continents have drifted around the globe. This means that the map of the world is constantly, but slowly, changing.

About 250 million years before present, all the continents were joined together in one giant continent called **Pangaea**. Since then they have slowly drifted apart.

The Earth's Plates

Fig.154

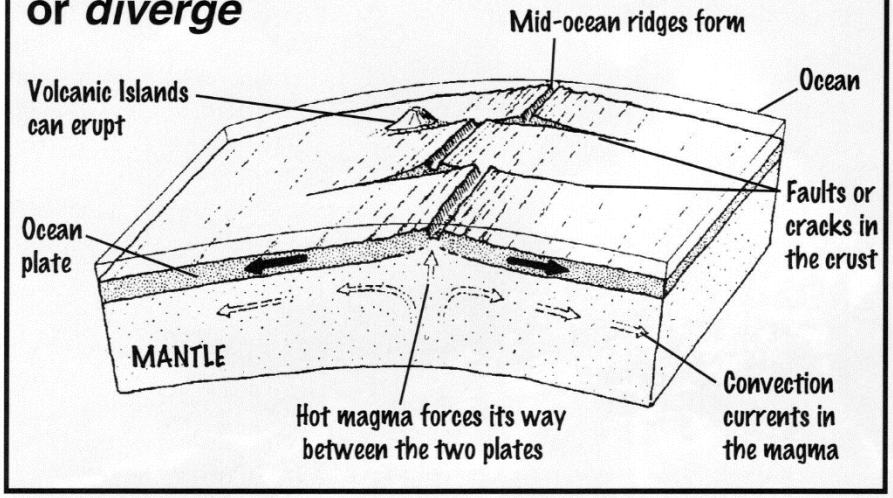


The plates are made of **basalt** (rocks formed from cooled lavas). Figure 154 shows the main plates and their general direction of movement across the world. As the plates move so to do the continents or oceans that they carry. Plates which carry oceans are usually very thin (between 5 - 10 km thick). Plates which carry continents are usually thicker (up to 70 km thick).

When two plates move apart (or **diverge**), their edges heat and curl up, forming ridges (fig.155). When two plates move towards each other (or **converge**) the thinner plate buckles under the thicker one (fig.156). As two plates slide past each other (fig.157), they form what is known as a **tear fault** (or crack). Earthquakes and volcanic eruptions are triggered as the huge plates move.

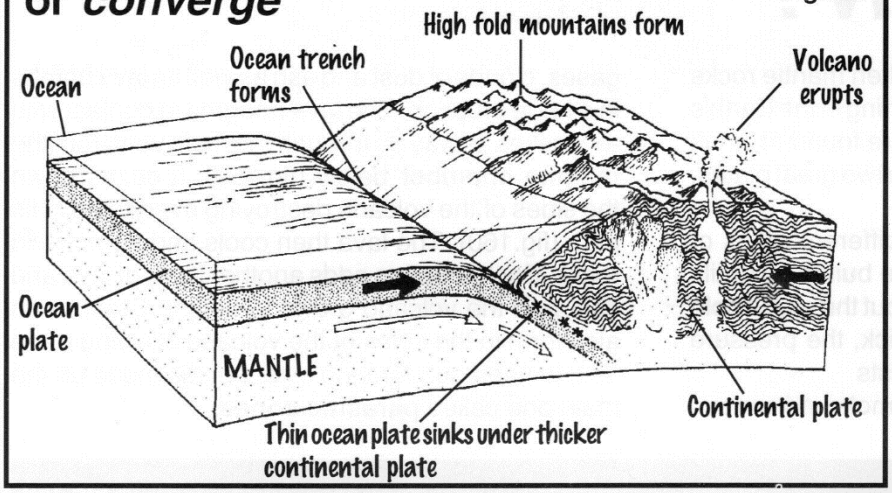
Where plates move apart or *diverge*

Fig.155



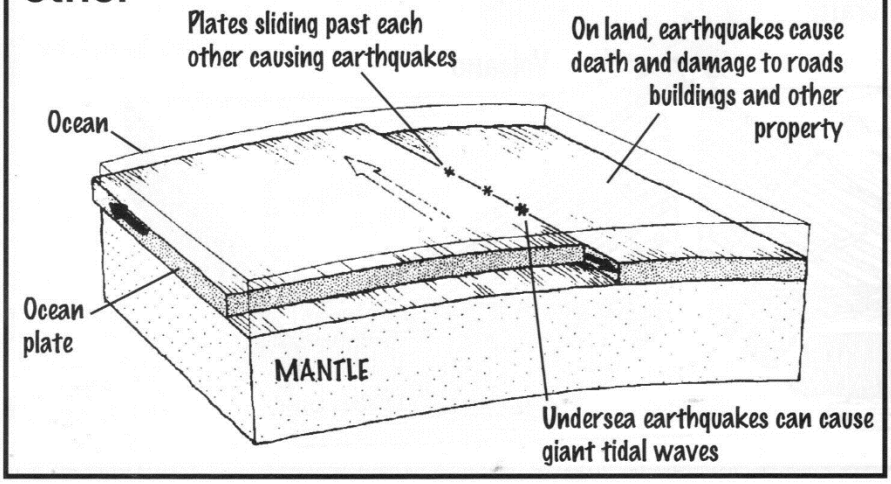
Where plates move towards each other or *converge*

Fig.156



Where plates slide past each other

Fig.157



Drifting Continents Tasks

1
i. What are **plates** ?
ii. What are plates made of ?
iii. How many plates are there approximately ?
iv. How do the plates **move**?

2
i. What was **Pangaea** ?
ii. What has happened to the continents and oceans since then ?
iii. Which ocean is getting wider ?
iv. Which ocean is getting narrower ?
v. Can you explain why ?

3
Look at figure **154**.
Give **two examples** of plates which are -
a. moving **apart**
b. moving **towards** each other.

4
i. Which are thicker, ocean or continental plates ?
ii. Why is this the case ?
iii. Which plate is the largest ?

5
What happens when the giant plates meet or part ? Write a **report** using your answers to questions 1 to 4 above and the information in figures **155** to **157**. You may use simple diagrams to help your answer.

SUMMARY

The Earth's crust is made up of approximately 15 giant plates which slowly move. The plates carry oceans and continents. As the plates move, the continents drift, oceans change shape and mountains grow.
Plate movement causes earthquakes and trigger volcanic eruptions.

Fig.158 Mt.Etna erupts at night

ERUPTION !

Volcanoes are formed when molten mantle rocks (**magma**) flow out through an opening in the Earth's crust (fig.158). Most volcanoes are found at weak spots in the crust, usually between two great plates.

The molten rock oozes out as different types of **lavas**. Deep in the crust pressure builds up until the magma forces its way up and out through a hole or **vent**. If the magma is very thick, the pressure can be so great that the lava bursts out in a giant explosion, sending smoke, poisonous gases, clouds of dust and ash as well as lava bombs in a huge eruption. The lava (magma in contact with air) makes its way up through the main vent from the **magma chamber** below (fig.159). It oozes down the sides of the volcano destroying everything in its path (fig.160). The lava then cools and forms solid rocks. Each eruption adds another layer of lava and ash, and the volcano grows in height. Cracks can also form in the sides of the volcano allowing more lava to seep out, forming smaller volcanoes on the main one called **parasitic cones**.

Inside a Volcano

Fig.159

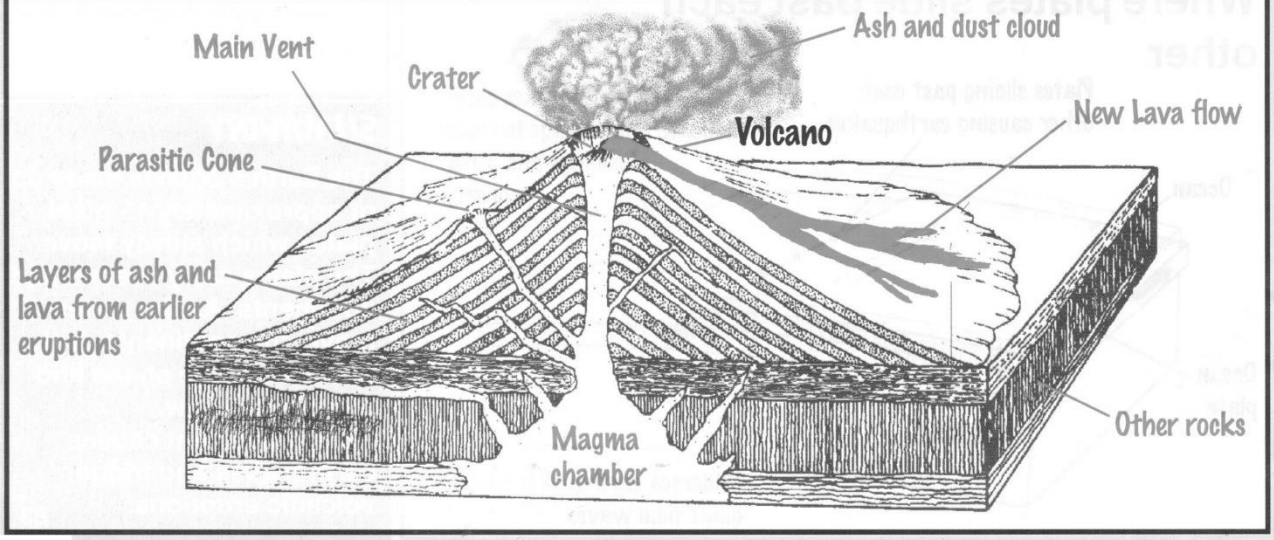


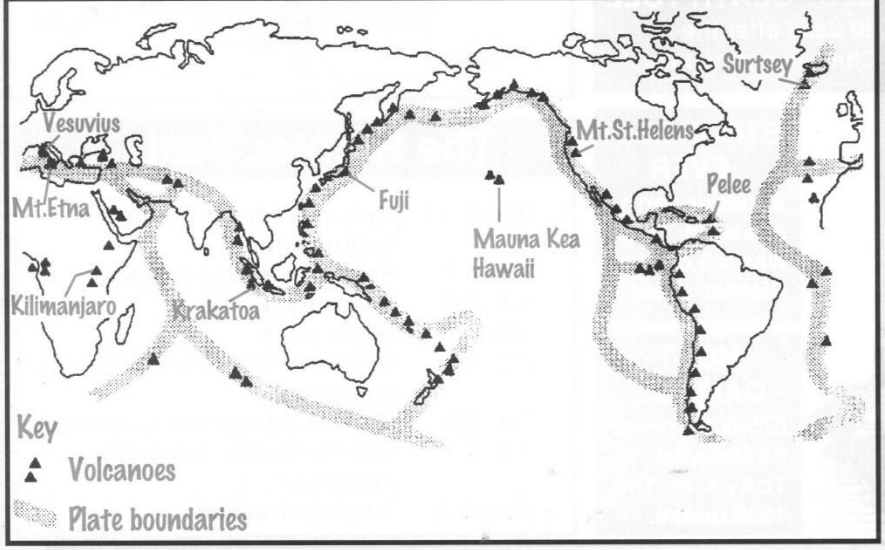
Fig.160 Molten lava flowing down Mt.Etna

When volcanoes are likely to erupt at any moment, they are said to be **active**, such as Mt.Etna in Sicily. Where a volcano goes quiet and does not erupt regularly, it is said to be sleeping or **dormant**, such as Kilimanjaro in Africa. If a volcano has not erupted for a very long time, it is said to be dead or **extinct**, such as Arthur's Seat, Edinburgh. Planet Earth has over 500 active volcanoes and probably 20 to 30 erupt in a year (fig.161).

Each eruption can bring death and destruction on a giant scale. When Mt.St.Helens erupted in May 1980, the top of the mountain blew off, ash and lavas covered the landscape and even trees over 60 kilometres away were blown over in the huge blast. Although volcanic eruptions destroy the landscape, plants, animals and property, many people choose to live near them. This can be because rich fertile soils form on volcanic areas and are good for farming on. In some volcanic areas there are valuable minerals to be found such as gold, silver, iron and diamonds. In Iceland, volcanic rocks near the surface are so hot that water found near them is used to heat houses or in power stations. Volcanoes also attract tourists since they are very beautiful. Volcanic islands in mid-ocean such as Hawaii are useful staging posts for long distance air or sea travel.

World Map of Volcanoes

Fig.161



Eruption Tasks

1
i. What is a **volcano** ?
ii. Write a sentence to explain each of the following - **vent, crater, magma chamber**

2
i. Draw your own simple diagram of a volcano (see fig.**159**).
Label the following features of a volcano on your diagram - crater, vent, magma chamber, magma, molten lava, ash cloud, layers of ash and lava.
ii. What do the layers of ash and lava tell you about the volcano ?

3
i. Look at figs **158** and **160**. Write a paragraph describing what each scene shows.
ii. What do the terms **active**, **dormant** and **extinct** volcanoes mean ? Give an example of each.

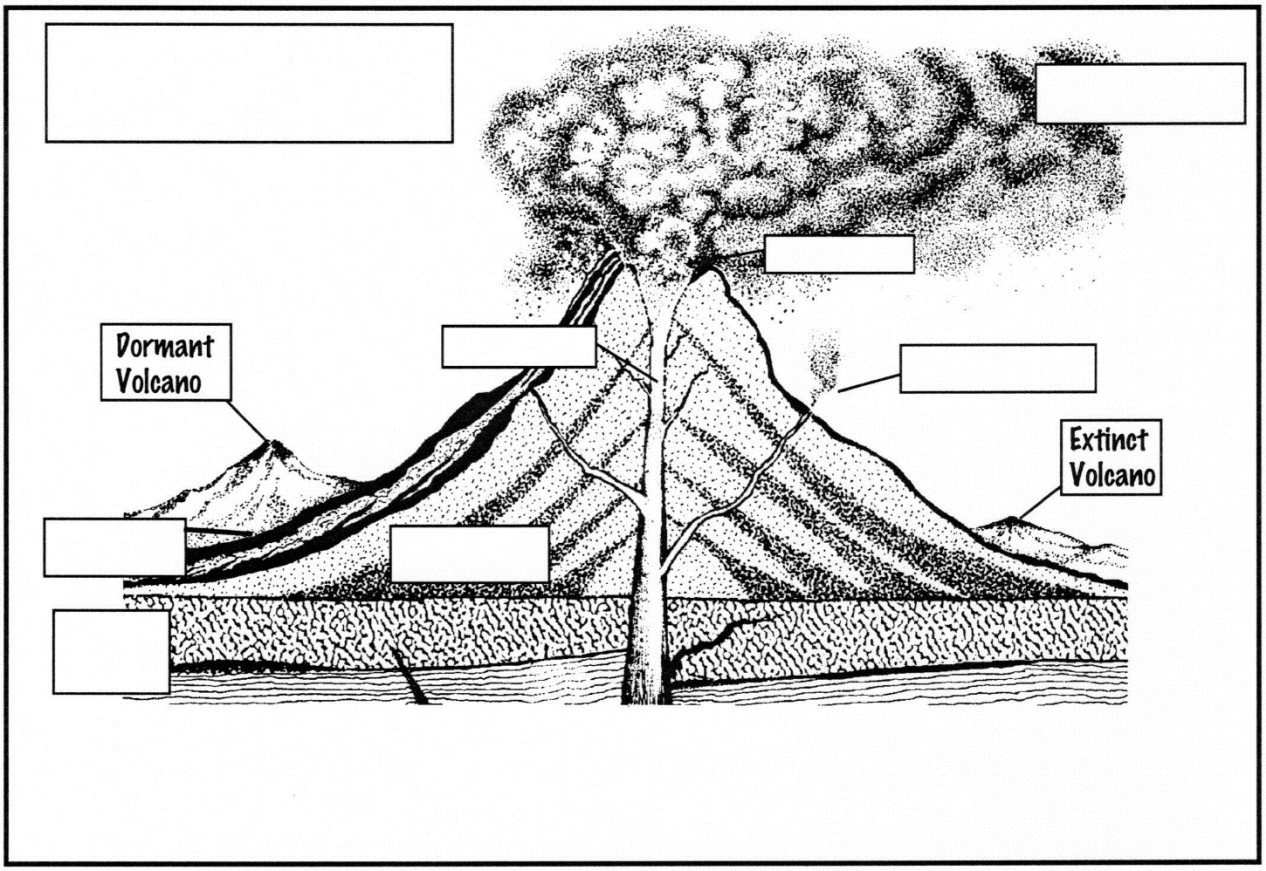
4
Where are volcanoes found on Planet Earth ?
Why are they found in these areas ?

5
Volcanoes can be very dangerous to live beside.
a. Describe the problems of living near to an active volcano such as Mt.Etna.
b. What then attracts people to live close to active volcanoes ?

SUMMARY

Volcanoes are formed when molten rock from the mantle erupts as lava through a vent in the crust. Volcanoes can be active, dormant or extinct. There are over 500 active volcanoes on the Earth. Volcanoes can bring death and destruction but people often live near them for good reasons.

Eruption !



1. i. Use figure **159** to help you fill in the boxes on the above diagram.
ii. Draw in and then label the **magma chamber** on the above diagram.
iii. Give the diagram above a title.
iv. In which direction was the wind blowing on the day of the above eruption ? _____

2. What is a **volcano** ? _____

_____

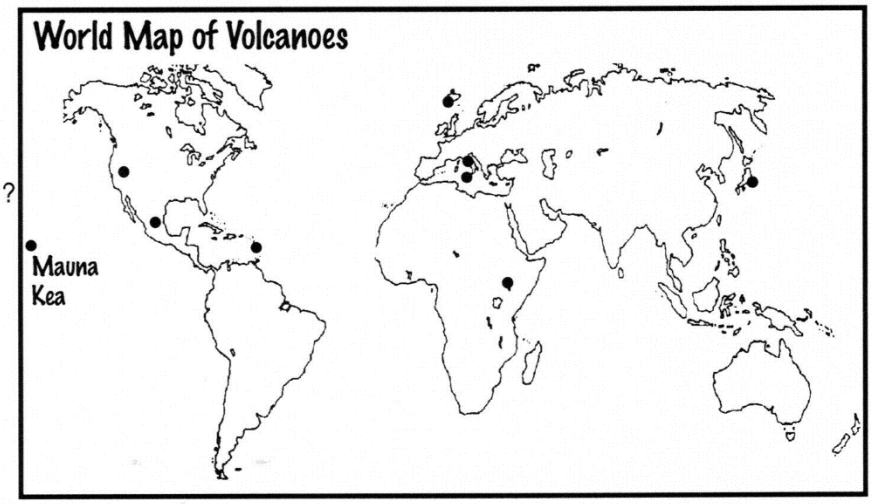
3. Use figure **161** and an atlas to help you mark in and name the following volcanoes on the map below **Mt.Etna, Mt.Vesuvius, Mt.St.Helens, Surtsey, Kilimanjaro, Pelee, Popacatypetl, Mt.Fuji, Mauna Kea**

Answer on the back of the sheet.....

4. Why are volcanoes found in these areas on the map ?

5. What do the terms **active, dormant** and **extinct** volcanoes mean ?

6. Are volcanoes **useful** to people ?
Give reasons for your answer.



QUAKING IN TERROR !

Every once in a while an earthquake makes the headlines causing death and destruction somewhere in the world. The 500,000 earthquakes every year remind us that the great plates of the crust are always slowly moving (fig.162).

An **earthquake** is a sudden movement in the crust; a series of shock waves passing through its rocks. Most earthquakes happen at the edges of plates, especially where two plates stick together. When the forces build up and the plates suddenly slip, the result is huge shock (or **seismic**) waves (fig.163). Earthquakes are usually followed by a series of aftershocks. The **focus** is the place where the rocks snap apart. Shockwaves travel out from the focus and are most damaging at the **epicentre** (the point on the surface above the focus). Earthquake strength is measured on the **Richter scale** (fig.164). Quakes measured over 6.5 cause major destruction. Like a scene from a disaster movie, buildings collapse, gas and water pipes snap, fires and explosions can kill millions in seconds. In the 1556 Chinese earthquake, over 830,000 people died.

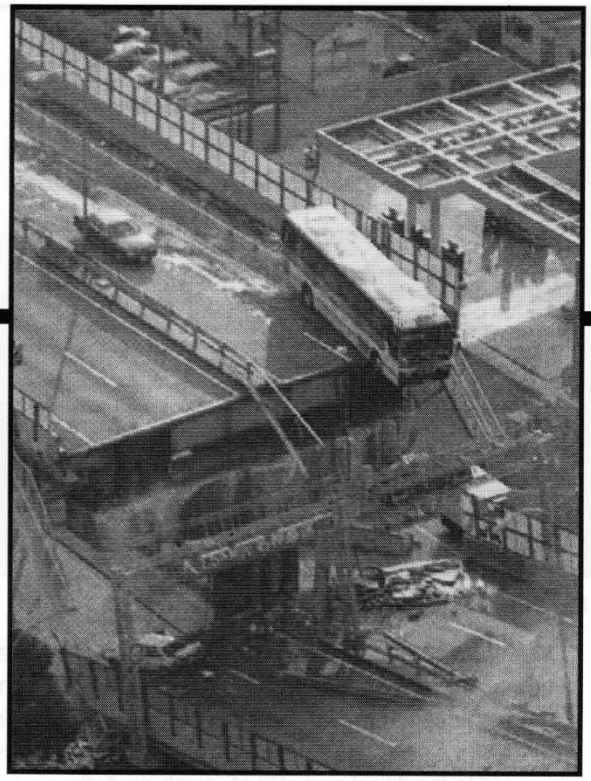
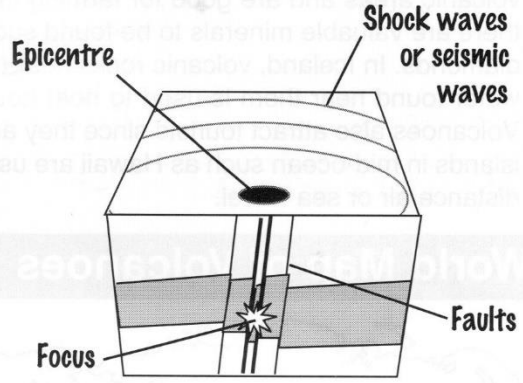


Fig.162 The after effects of the **Kobe 1995** earthquake - roads and bridges destroyed

When an earthquake happens undersea, a huge tidal wave (or **tsunami**) can form and create major flooding and damage along low coastlines. Scotland, too, has earthquakes (fig.165). So far we have been lucky but you never know !

Epicentre and Focus

Fig.163



Quaking in terror !

Fig.164

Over 500,000 quakes of all types happen each year. 100,000 can be felt and 1,000 cause damage.

BIGGEST DEATH TOLL
830,000 dead after the 1556 Chinese earthquake

STRONGEST EVER
Valdivia Earthquake, Chile, 1960 −9.5 on the Richter scale

MOST DAMAGE
575,000 homes destroyed in Tokyo in the 1923 quake.

The Richter Scale

Under 3.5	Only recorded by sensitive instruments
3.5 - 4.8	Feels like a lorry passing
4.9 - 5.4	Loose things fall
5.5 - 6.1	Walls crack
6.2 - 6.9	Chimneys fall. Some buildings collapse
7.0 - 7.3	Many buildings fall. Landslides
7.4 - 8.1	Most buildings and bridges destroyed
Over 8.1	Total destruction

Fig.165

Aviemore shakes in wake of earthquake

Tremor rocks holiday area

An earthquake struck a Highland holiday area yesterday, shaking buildings and terrifying local people. Worried residents contacted the police to find out what had happened after the tremor struck at 11.00 am.

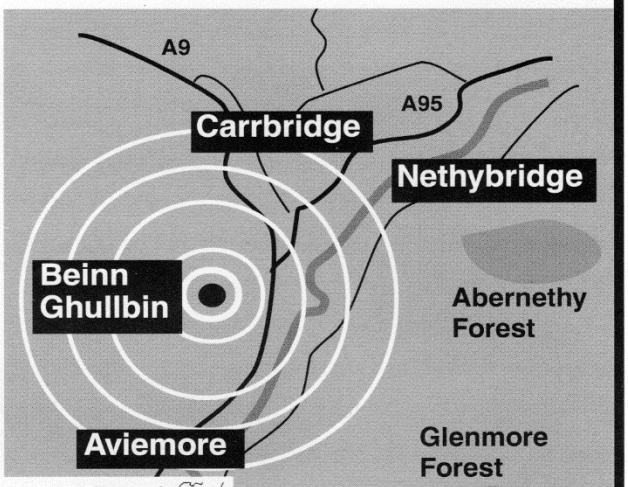
People living within a 15 kilometre radius of Aviemore reported hearing a loud bang and homes and offices shook for about a minute.

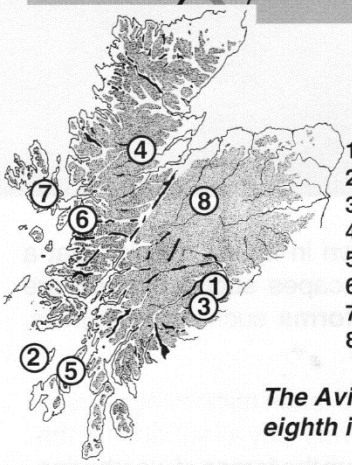
The quake measured 2.7 on the Richter scale and was centred 7 kilometres below Beinn Ghuilbin, 6 kilometres north of Aviemore, close to the main A9 road. The effects of the quake were felt in Aviemore, Carrbridge and Nethybridge and many small settlements nearby.

Aviemore Mountain Resort boss, Don Lawson said, "I was on the phone in the hotel when all the glasses started to clink and the lights flickered. It's a big building and the whole thing was shaking.

It sounded like an explosion or that something had fallen out of the sky and landed on the roof. It was awesome !"

Alice Walker from the British Geological Survey in Edinburgh said, "We've been recording for 30 years and this has not happened in Aviemore before. But quakes can happen anywhere. There are about 300 to 400 a year in Britain. Only about 20 are detected by the public. Scotland averages 2 or 3 quakes a year. It is unlikely that there will be aftershocks in the Aviemore area so residents need not worry. This one was deep underground. If they are deep, they don't cause much damage."





Scotland's Quakes

	Date	Place	Size
1.	1990	Glen Lyon	2.5
2.	1990	Colonsay	3.0
3.	1991	Balquidder	2.8
4.	1992	Strathcarron	2.8
5.	1992	Jura	2.7
6.	1993	Mallaig	2.7
7.	1994	Skye	3.1
8.	1995	Aviemore	2.7

The Aviemore quake was the eighth in Scotland since 1990

Quaking in Terror ! Tasks

1 i. What is an **earthquake** ?
ii. What is a **tremor** ?
iii. What happens when there is a large earthquake undersea ?

2 i. Why do earthquakes happen ?
ii. Make your own copy of figure **163**.
Write the following labels on your diagram - **Epicentre, Focus, Faults** (cracks in the crust), **Shock waves, Crust**.
iii. What is the point at which most damage happens in an earthquake ?
iv. Copy out the **summary** below into your notebook.

3 Imagine you are a newspaper reporter interviewing a passenger from the bus in figure **162** during the 1995 Kobe earthquake. What questions do you ask her and what answers does she give you about what happened ?

4 Describe the effects of an earthquake measured on the **Richter scale** at -
a. 3.1 b. 8.6 c. 5.8

5 Look at figure **165**. Write your own **report** on the Aviemore earthquake and its effects on the holiday area.

6 Scotland has had several earthquakes in recent years. Can you give reasons why it is **unlikley** that a major earthquake (of over 8.1 size) will happen in Scotland ?

SUMMARY

Earthquakes are sudden movements in the crust. They are common along plate edges. Earthquakes cause death and destruction on a massive scale. Earthquakes can be measured on the Richter scale.

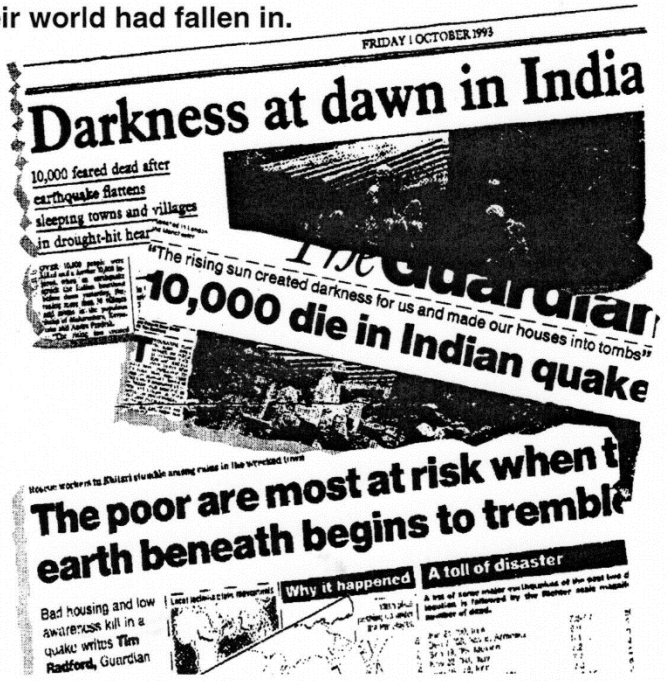
1. Make a **video or radio news report** about the **Indian** earthquake using the information below.

Based on information from XFAM Working for a Fairer World

The Indian Earthquake

47 seconds that shook the world

At 4.00am ON SEPTEMBER 30TH 1993 an earthquake rocked Maharashtra State, India for 47 seconds. It wasn't a major 'quake,. It measured only 6.4 on the Richter scale. It struck in a small area, just 40 km across. But for hundreds of thousands of people living in the area, the damage was done. Their world had fallen in.



IT SOON BECAME CLEAR. This was a 'quake of huge proportions. It struck at the worst possible time at night when people were asleep. Thousands of homes were turned into tombs in just under a minute; the poorly built housing having no chance of standing up to the shock. No one will ever know for sure how many people were killed.

Whole villages were destroyed, and their people all but wiped out. Killari, the village closest to the epicentre of the earthquake, was home to 22,000 people. Nearly 18,000 died that night. It is thought that up to 30,000 people were killed in total by the earthquake in Maharashtra state. The numbers of injured and homeless can still only be guessed at, though estimates now say anywhere between 150,000 and 300,000 people could be affected.

Picking up the pieces afterwards

With such destruction and devastation it can be many years before these broken communities can put their lives back together again. But a start has already been made.

All badly affected villages have now been given new, but temporary, sites. The Indian Army, helped by quake survivors and other volunteers, built wooden living quarters for the homeless. Washing areas and toilets are also being built all over the state to prevent disease spreading during the rainy season. At first there were food shortages as many roads, railways, bridges, lorries and food stores had been crushed by the earthquake. But new bridges and army lorries and helicopters have made sure that all people living within the quake zone are being well fed. New crops have been planted in time for the rainy season but there is still a major lack of storage space for food.

Oxfam's Aid to the area

Within six hours of the earthquake, Oxfam, one of the world's most important and successful aid organisations, had two workers in the disaster area. They immediately began to help organise the relief work. Having worked in the area with local people for many years, Oxfam were able to help where and when it mattered most. Through their network of partner agencies Oxfam were able to provide emergency shelters and water supply equipment, and help send food to the survivors who needed it most.

DISASTER STRIKES!

By IAN BLACK

A MASSIVE earthquake killed thousands of terrified men, women and children as it struck Mexico yesterday.

At least 1,000 people are known to have died in Mexico City alone and thousands more were injured.

The quake struck the world's largest city – population 18 million – at the end of the morning rush hour, demolishing schools, high-rise apartment buildings, office blocks, churches and hotels.

Another big death toll is feared in the paradise resort of Acapulco on the Pacific Coast and near to the 'quake's epicentre 40 miles offshore.

Fires broke out as gas mains exploded, and with the capital's main communication tower ablaze, the full horror of the huge 'quake – 7.8 on the Richter scale – came through to the world in snatches at first.

A government radio operator managed to get through to an amateur operator in the US to report that about a third of the city had been devastated.

Later a US satellite picked up coverage by local Mexican TV.

EMERGENCY

It showed scenes of appalling devastation as men and women scrabbled on their hands and knees to free friends and relatives trapped under thousands of tons of rubble.

On the Avenue de la Reforma one 13-storey block of flats of 300 family homes collapsed.

And at a busy, modern hotel used by tourists and visiting businessmen the screams of trapped victims could be heard for over an hour.

Last night every hospital still able to operate was working on full emergency footing with the wards packed with injured and dying.

Rescue work went on into the night with firemen, police and civilians sifting among the ruins for survivors.

Firemen were also busy containing blazes triggered by the earthquake.

But conditions for rescue work were appalling.

A third of the sprawling city was without either light or water and petrol for emergency vehicles was in short supply.

Blood for the injured was also running out and the government appealed for donations.

Police last night began evacuating millions of citizens.

The Mexican military appealed for other people to stay off the streets, and remain indoors in areas least damaged by the 'quake.

Some reports said the army was standing by to prevent looting – a major fear in a country hit by appalling economic problems.

The authorities have ordered rescue helicopters to stop flying over the city because, they say, the vibrations from the aircraft rotor blades could cause other buildings to come tumbling down.

With almost no communications to other earthquake areas, the final death toll will not be known for days.

(*Daily Express*, 20 September 1985)

Read the newspaper extract above.

1. What is the population of Mexico City?_____
2. How much of the city was devastated by the earthquake?

   _____
3. What is the name of the resort where another big death toll was expected?

   _____
4. Why will it take days before the final death toll is known?

   _____

   _____

   _____
5. Describe **two** problems facing rescue workers immediately after the earthquake in Mexico City.

   _____

   _____

   _____

   _____

Earthquakes

1. What exactly is an **earthquake** ?

_____

_____

_____

2. Use figure **163** to help you draw and label a diagram to show an earthquakes **epicentre** and **focus**. Draw your diagram in the box alongside.

3. How do earthquakes happen ? _____

_____

_____

4. What are **seismic waves** ? _____

_____

_____

5. Earthquakes are measured on the **Richter** scale.
   i. What happens in earthquakes measured at over **8.1** on the Richter scale ?

_____

_____

   ii. Which earthquakes this century registered over 8.1 on the Richter scale ?

_____

_____

_____

Answer the following questions on the back of the sheet.

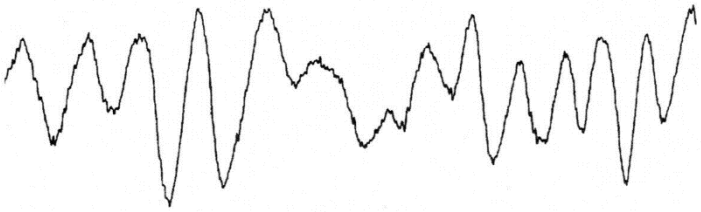
6. **Find out** about the following -
   i. The **Mercali earthquake scale.**
   ii. The world's major earthquakes since
   Make a list like the one alongside.
   naming the origin of earthquakes over 8.0.

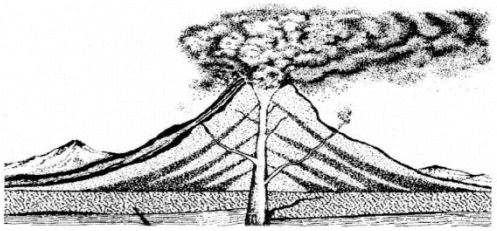
   iii. Why **Scotland** suffers only small earthquakes.

Earthquakes, Epicentre and Focus

Major Earthquakes of this century

Magnitude	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
8.0+	1	1	0	1	2	1	2	4	0	1	1	1	2	2	1	1	0	1	1	1
7-7.9	14	15	13	14	14	10	9	14	12	16	23	19	12	17	11	18	16	6	16	9
6-6.9	146	121	127	140	141	140	142	178	168	144	150	185	108	123	143	127	130	104	117	135
5-5.9	1344	1224	1201	1203	1515	1693	1712	2074	1768	1896	2209	2276	1401	1453	1574	1419	1550	1455	1674	1492
Estimated Deaths	231	21357	1685	33819	298101	87992	6605	708	88708	1790	226050	21942	689	1572	756	9624	1297	1012	4535	244





RESTLESS EARTH PROJECT

Your task is to plan and carry out a **Restless Earth Project.** There are several stages to work through. These are listed below.

Stage One Choose **ONE** famous volcanic eruption **OR** earthquake. Choose carefully as there are many different examples of each. For example, you could choose from many different volcanic eruptions such as Mt.Etna, Krakatoa, Mt.Vesuvius, Mt.St.Helens, Nevada del Ruiz, Surtsey, etc. Or you may choose to study an earthquake such as that of Tokyo 1923, San Francisco 1906, Armenia 1988, Agadir 1960, Los Angeles 1989, India 1993, Mexico City 1985, etc.

Stage Two **Find out** about your choice of volcanic eruption or earthquake. Use geography textbooks, geographical magazines, newspaper reports, video clips & programmes, the school library, encyclopedias, Guinness Book of Records, CDRoms, and so on.
Make written notes and sketches, collect pictures, etc about the following headings :-

Where the event happened
When the event happened
What caused the event
How long the event took to happen
What actually happened during the eruption/quake
What the effects on the landscape, local people, animals, plants, buildings, jobs, etc were.
What the aftermath of the event was
What can be learned from the event.

Stage Three Carefully **plan** how your will report about your choice of eruption or quake. Make a simple **storyboard** - a series of boxes which show in simple form how you will cover the headings above.

Stage Four **Present** your project as either a **booklet** or **poster**. Your finished project should be presented in a clear, attractive and sensible manner, with good use made of colour and and written text. Remember to give your project a **title** and your name and class written clearly in the top right hand corner.

Restless Earth Test 1

Name	Class	Date	/40

Answer the following questions after studying pages 80 to 87 of the textbook.

1. What is a **volcano** ? _____

_____ (2)

2. In the box below, draw and label a diagram of an **active volcano**. (11)

3. For each of the following **circle** the correct answer -

i.	The **Ocean** crust is made up of mainly...	Granite	Basalt	Sandstone	Chalk
ii.	The **Continental** crust is made up of mainly....	Granite	Basalt	Sandstone	Limestone
iii.	The outer skin of the Earth is called the...	Core	Mantle	Crust	Ocean crust
iv.	The Inner Core of the Earth is made up of....	Granites	Red-hot molten metals	Solid, white-hot nickel & iron	Heavy rock called basalt
v.	Vesuvius is an example of.....	a Crater	an Active volcano	a Dormant volcano	an Extinct volcano

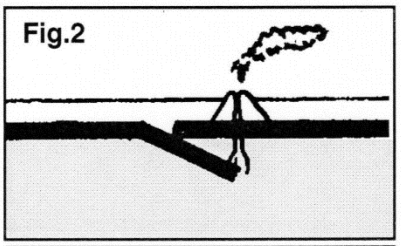
(5)

Restless Earth Test 2

4. Look at the two diagrams opposite.
Both show ways in which plates move.

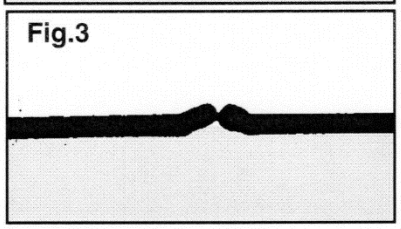
i. Figure **2** shows two plates

Converging
Diverging
Moving vertically
Stuck together ①



ii. Figure **3** shows two plates -

Converging
Diverging
Moving vertically
Stuck together ①



iii. In which other way do the giant plates move ? _____ ①

iv. Draw a simple diagram to show this movement in the box below. ③

5. Which is the largest plate on the Earth's surface ?

_____ ①

6. Make a list of three effects that happen when there is an **earthquake**.

1. _____

2. _____ **3.** _____ ③

7. How are earthquakes measured ? _____

_____ ③

8. Where are earthquakes common and why ? _____

_____

_____ ③

9. Make a list of three advantages and three disadvantages of **volcanoes** for the people who live near them.

Advantages _____

Disadvantages _____

⑥