Chapter One – The Restless Earth

The Restless Earth

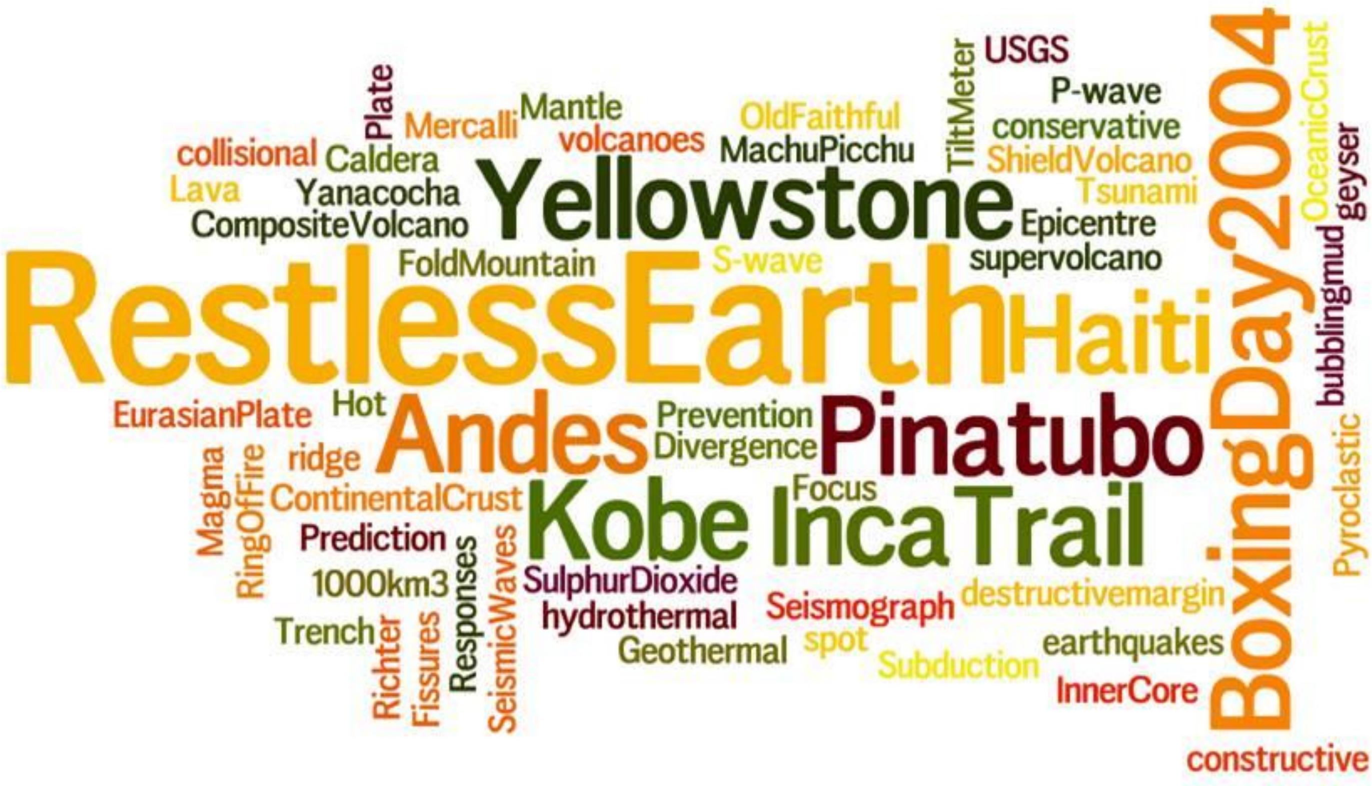
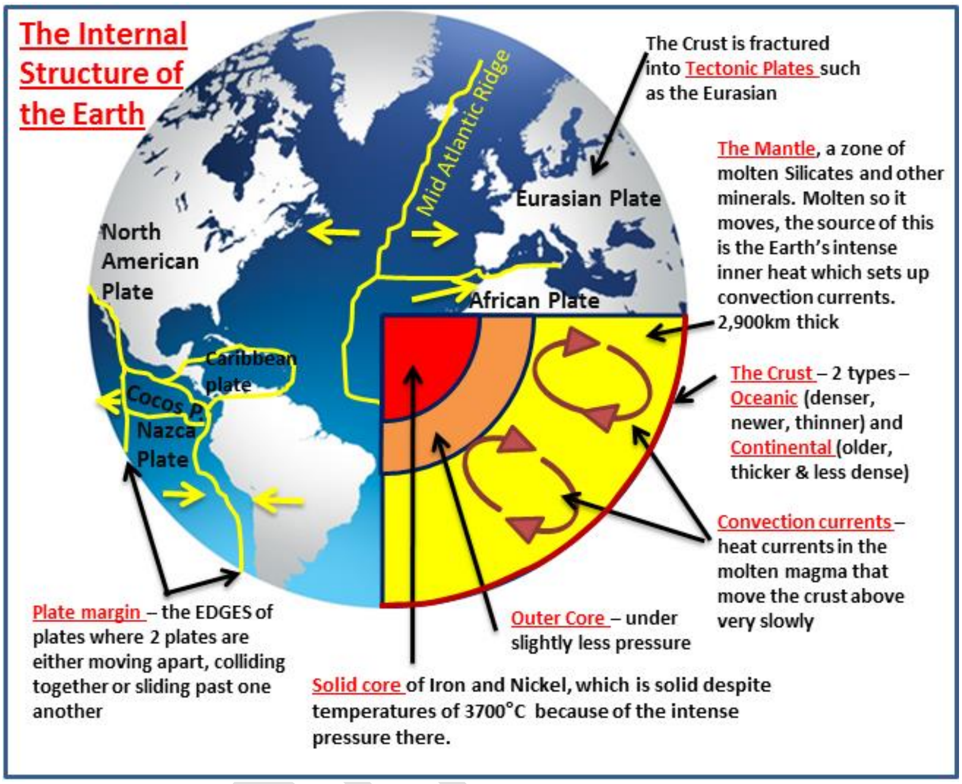


Plate Tectonics and the structure of the Earth



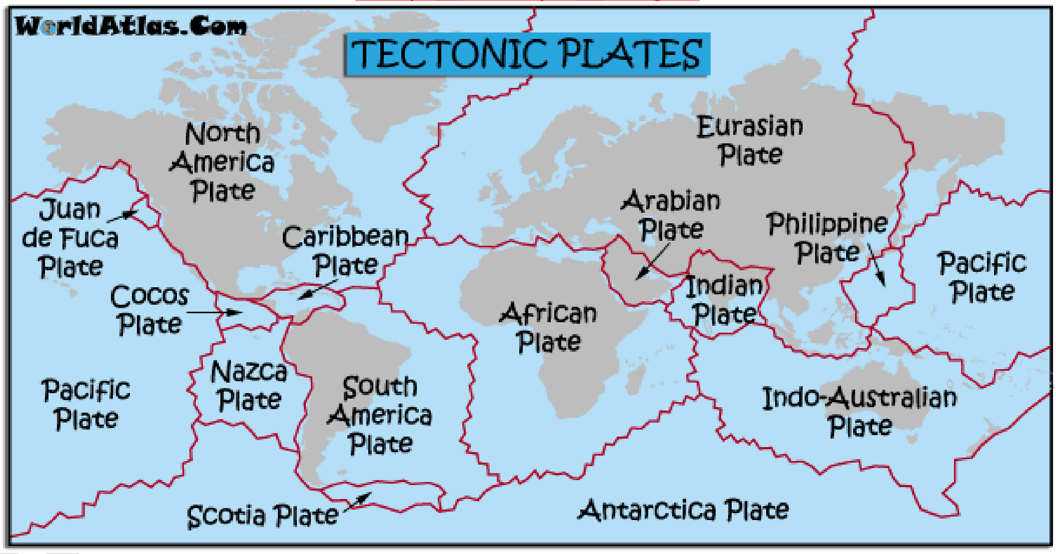
Tectonics is a theory that tries to explain how the Earth is structured and what it is made up of.

To the right is an idealised diagram of the Earth's interior (middle bit). The Earth formed approximately 4.5 billion years ago following a huge explosion of a star. The materials that make up our earth slowly gathered together due to gravity, to create a ball of hot molten material. This material has slowly cooled over geological time, forming a crust at the Earth's surface of rocks. These rocks are fractured into huge segments called Tectonic plates.

These tectonic plates are moving about very slowly, pushed and shoved around from underneath by currents within the mantle called convection currents.

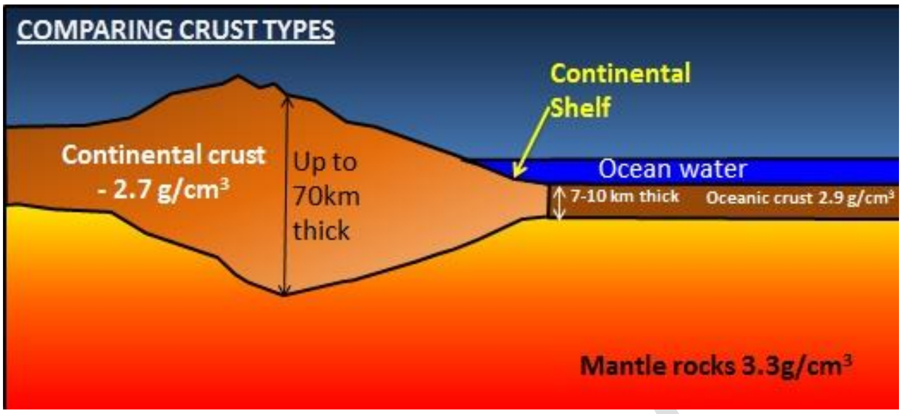
Beneath the crust temperatures start to rise as you descend into the second of the Earth's zones, the Mantle, a zone of molten Silicates and other minerals. The Earth does have a solid core of Iron and Nickel, which is solid despite temperature of 3700°C because of the intense pressure there.

The plates and plate margins



The Tectonic Plates vary in size and the Earth's surface can be likened to that of a boiled egg which has been cracked. The major plates include the Pacific, Eurasian, African, Antarctic, North American and South American, and the Indo-Australian. There are other smaller plates however, such as the Philippines and Cocos plates. The tectonic plates join at zones called plate margins, where most of the world's volcanic and earthquake activity occurs.

The plates are made up of different materials, and there are 2 broad types;

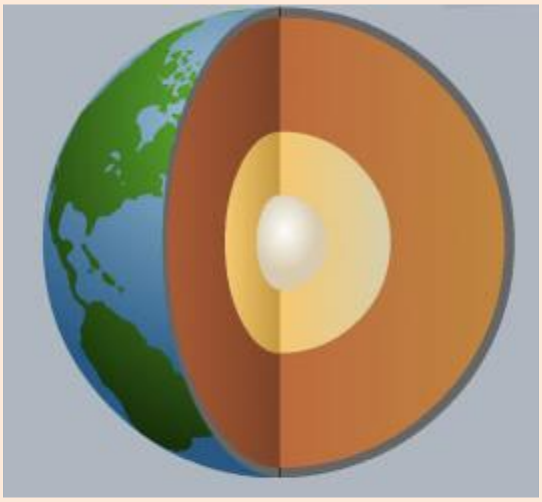


Continental crust is thicker, older and lighter, and is composed mainly of Granite. It is 22 mi (35 km) thick on average and less dense than oceanic crust. Continental crust is more complex than oceanic crust in its structure and origin and is formed primarily at subduction zones at destructive plate margins.

Oceanic crust is younger and heavier, and is mainly composed of basalt and Gabbro. It is mainly formed at constructive margins or spreading mid ocean ridges.

ACTIVITIES – 1.1

1. Fully label the diagram below, then add one fact about each zone of the Earth's Structure



2. Define the terms;

a) Tectonic Plate____

b) Plate margin____

3. Contrast the characteristics of continental and oceanic crust

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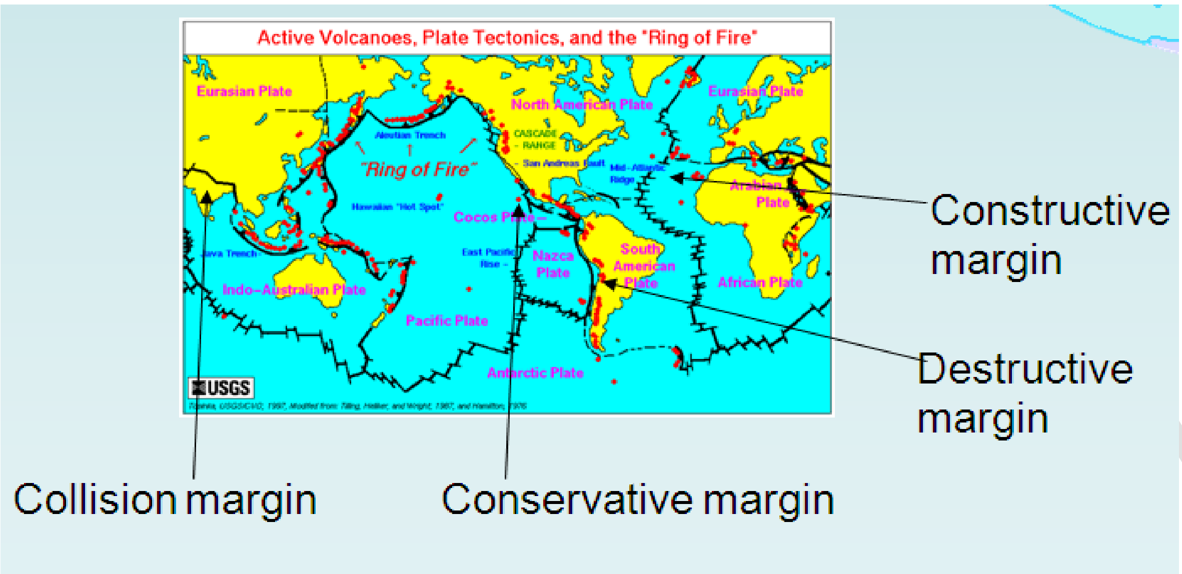
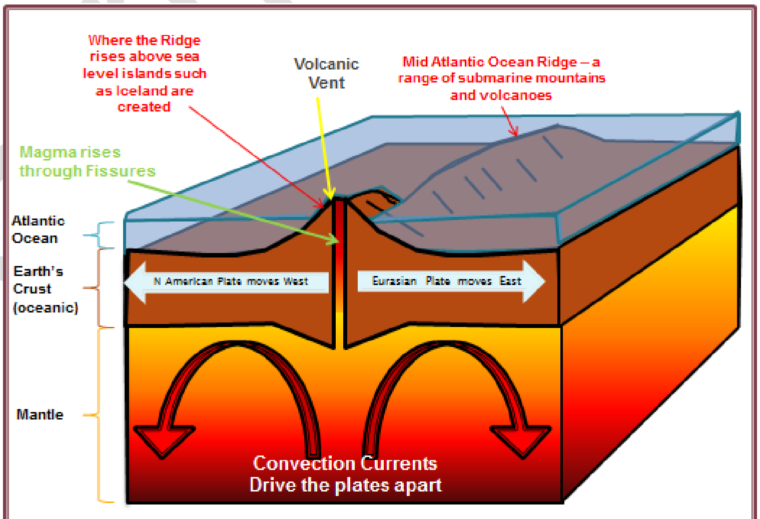
Types of plate margin



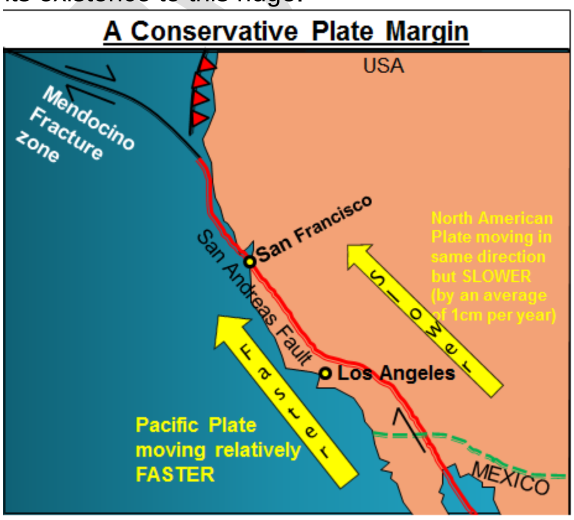
Volcanoes and earthquakes mainly occur along plate boundaries where magma can escape from the Earth's mantle or where stresses build up between 2 plates rubbing together. An exception to this includes Hawaii, which is found in the middle of the Pacific plate over a hot spot.

Constructive or Divergent Margins

At this type of plate margin two plates are moving apart (DIVERGE) from each other in opposite directions. Convection currents moving in opposite directions (caused by the intense heat of the Earth's interior) in the mantle move two plates apart. As these plates move apart this leaves cracks and fissures (lines of weakness), that allows magma from the mantle to escape from the highly pressurised interior of the planet. This magma fills the gap and eventually erupts onto the surface and cools as new land. This can create huge ridges of undersea mountains and volcanoes such as the Mid-Atlantic Ridge; and where these mountains poke above the level of the sea, islands are created. Both earthquakes and volcanoes can result at these margins, the earthquakes caused by the movement of magma through the crust. A really good example of this is the Mid-Atlantic Ridge, where the Eurasian plate moves away from the North American plate at a rate of around 4cm per year. Iceland owes its existence to this ridge.



A constructive or DIVERGENT plate margin

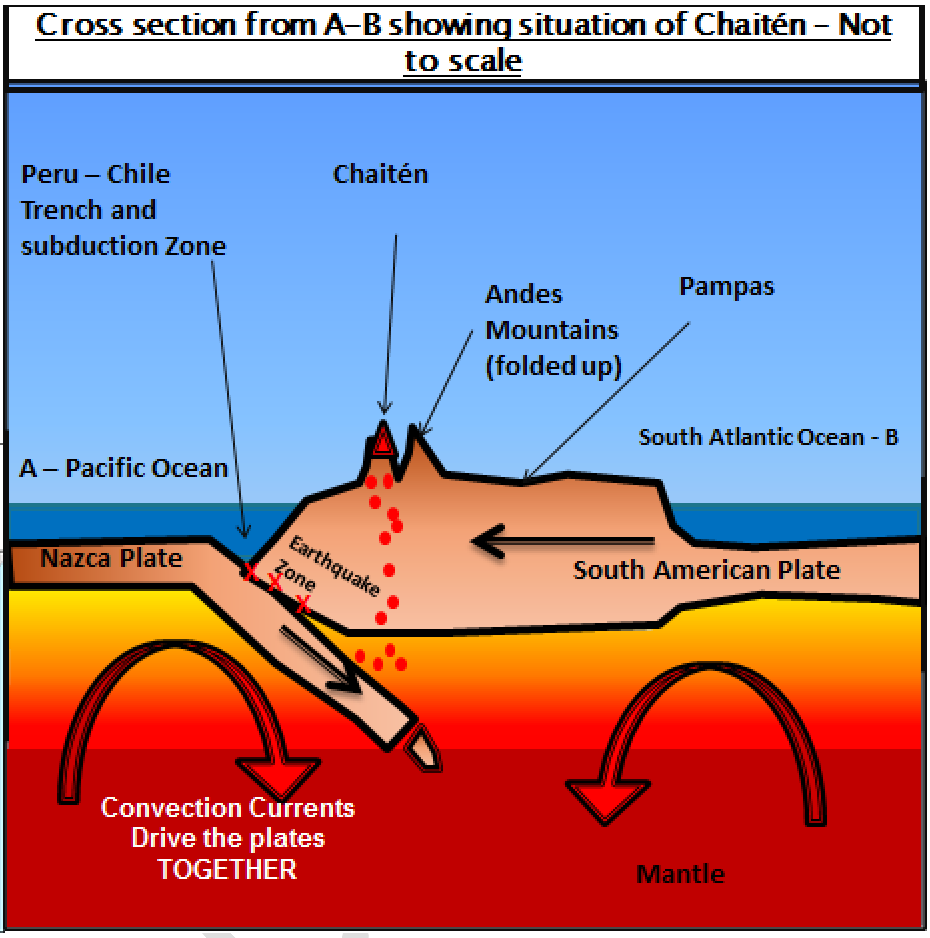


Conservative margins

At conservative margins mountains are not made, volcanic eruptions do not happen and crust is not destroyed. Instead, 2 plates either slide past each other in opposite directions, or 2 plates slide past each other at different speeds. As they move past each other stress energy builds as the plates snag and grind on one another. When this stress energy is eventually released it sends shock waves through the earth's crust. We know these shock waves as earthquakes, and a good example of this is the San Andreas Fault in California, where the Pacific plate is moving NW at a faster rate than the North American plate.

Destructive or Convergent Margins

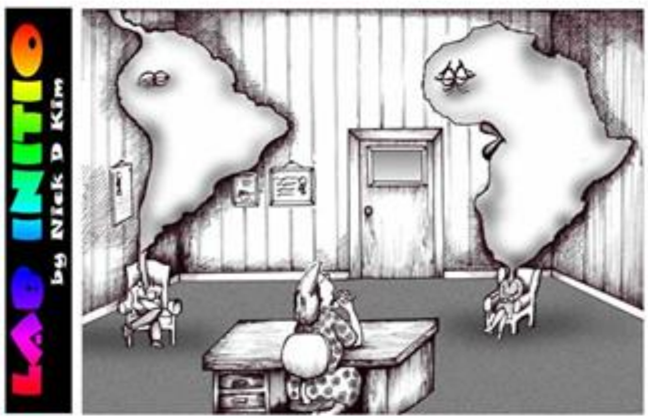
A Destructive (CONVERGENT) Plate Margin – The Andes Mountains in South America



At these margins 2 plates move or CONVERGE together and the Destruction of some of the Earth's crust results. An oceanic plate (denser) is pushed towards a continental plate (less dense) by convection currents deep within the Earth's interior. The oceanic plate is subducted (pushed under) the continental plate at what is called a subduction zone, creating a deep ocean trench. It is the Oceanic crust which sinks down into the mantle because it is denser (heavier). As it descends friction, increasing pressure and heat from the mantle melt the plate. Some of this molten material can work its way up through the continental crust through fissures and cracks in the crust to collect in magma chambers. This is often some distance from the margin where magma can eventually re-emerge at the surface to create a range of mountains. The movement of the plates grinding past one another can create earthquakes, when one plate eventually slips past the other releasing seismic energy. There are several really good examples of Destructive plate margins, including along the West coast of the Americas and Japan, where the Philippines sea plate is pushed under the Eurasian plate.

Collisional

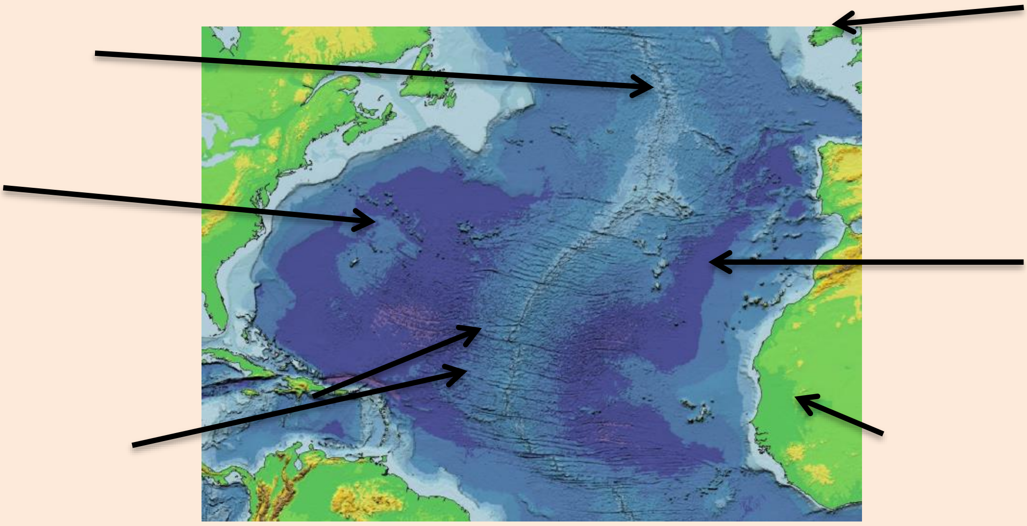
At these margins 2 plates of similar density are forced toward each other. Neither plate descends into the mantle because of the similar density of the plates. Instead, the 2 plates crumple into one another and fold upwards into Fold Mountains. At these margins we get Fold Mountains and earthquake activity, and a fantastic example of this is the Himalayan Mountains. Here, the Indo Australian plate is colliding with the Eurasian plate and has done so for millions of years. Originally, there used to be a sea called the Tethys Sea between India and Asia, but over time India has collided into Eurasia creating huge fold mountains rich in marine (sea) fossils!



"Well, looking back I suppose it's been going on for quite some time... but I only noticed we were drifting apart during the last 50 million years..."

ACTIVITIES 1.2

1. Add the following labels to the satellite image of a **CONSTRUCTIVE** plate margin below – North American Plate, Eurasian Plate, The Mid Atlantic Ridge, Fault lines, West Africa and South West Ireland



2. Complete the flow chart below to explain exactly what happens at **Destructive** plate margins. Mention subduction, oceanic crust, continental crust, earthquakes and volcanoes in your flow chart.

3. Explain why we get earthquakes but not volcanoes at **CONSERVATIVE** plate margin____________________

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Landforms found at plate boundaries

The 4 basic landforms that you need to know found at plate boundaries are Fold Mountains, mid ocean ridges, ocean trenches and types of volcano.

Fold Mountains are large mountain ranges where the layers of rock within them have been crumpled as they have been forced together. They can be formed at destructive or collisional plate boundaries, where tectonic plates are moving together forcing layers of rock to be crumpled upwards.

The process of formation is as follows;

1) Sediments accumulate in shallow seas or depressions as rivers enter those areas.
2) This creates a sea or lake bed of layered sedimentary rocks as compression takes place.
3) Two plates move together because of convection currents in the mantle
4) This starts to crumple the rocks together.
5) The rocks start to form folds which have anticlines and synclines, which are pushed upwards to form fold mountains.
6) These mountains are then subject to erosion, weathering and mass movement (denudation)

Ocean Trenches

These are deep water areas that run along a coastline which has a destructive plate margin. They are created by subduction, and mark the point where the Oceanic crust is being pushed under the Oceanic crust.

There is often quite a large section of continental crust between this margin and the ocean's edge, and sometimes a volcanic island arc such as Japan can be found in between the trench and the continental shelf.

These are not to be confused with mid ocean ridges, which are long ridges of mountains created by 2 plates moving apart at a constructive plate margin. Where these mountains rise above the level of the sea, Islands such as Iceland are formed.

ACTIVITIES 1.3

1. DISTINGUISH between Ocean trenches and Mid Ocean Ridges____________________________________

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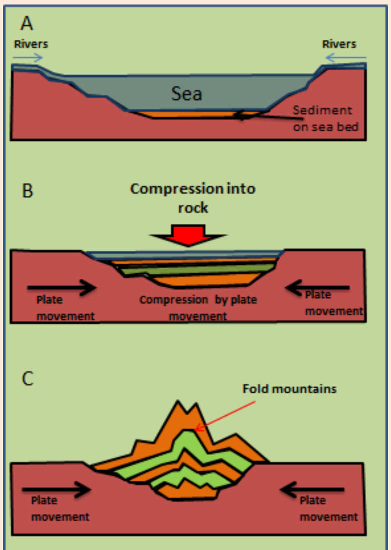
2. For each stage of the fold mountains diagram explain what is happening and how they form.



The formation of fold mountains

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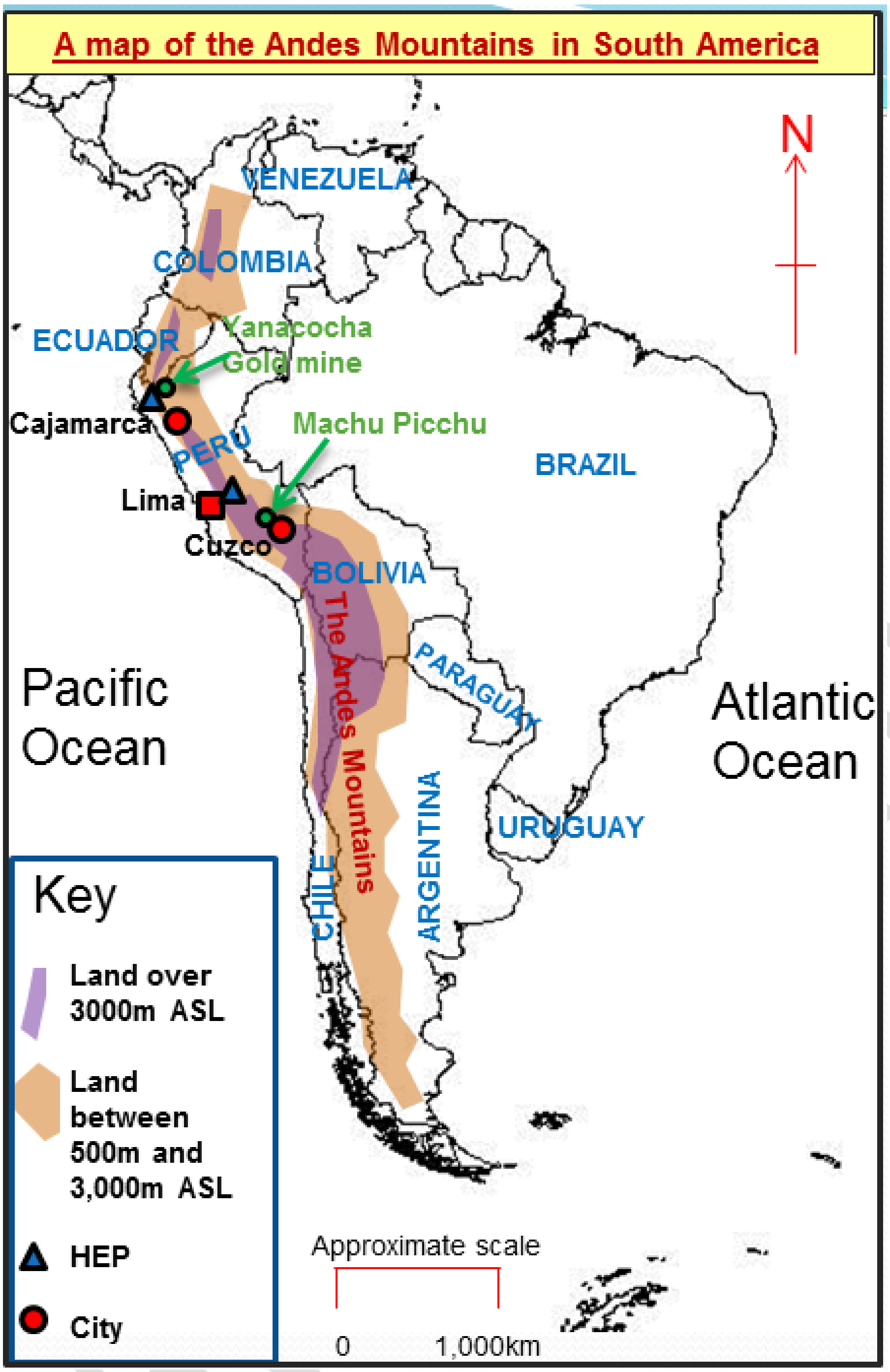
Andes Mountains - a case study of how Fold mountains are used



About the Andes Mountains

The Andes Mountains run the length of the West Coast of South America, rising in the North in Colombia and finishing in Chile and Argentina in the South. They are world's longest mountain range running for over 7,000km and covering 6 countries.

The mountains have been formed as the rocks of the South American plate have been folded upwards and crumpled into fold mountains. There are also Volcanoes and earthquakes along this destructive plate boundary - earthquakes caused by stresses building up as the 2 plates try to move past one another, and volcanoes caused by magma working its way up through vents in the Earth's crust. The trench (marking the boundary between the Nazca and South American plates) to the West of the Andes mountains is called the Peru-Chile Trench, and reaches an incredible depth of 8066m under the sea level.

Why is it difficult to live in Fold Mountains?

These areas are very hard to live in because of the physical geography. The relief is very steep making farming difficult, and the high altitude makes breathing difficult. The mountainous terrain makes it difficult to construct roads and railways to allow for communications. In addition, the tectonic forces which create these mountains and push them up over make the area vulnerable to landslides, earthquakes, rock falls and volcanic eruptions. There are advantages of fold mountains however, as listed below.

How the Andes Mountains are used

Farming

The mountain slopes of the Andes are used for a variety of farming practises. The best land can be found on the valley floors, but a clever system of terraces dug into the valley sides and held up by

retaining walls has been used to bring the lands on the valley sides into food production. The flat terraces help to hold up water in a region where there are marked shortages. Most crops are grown in the lower areas and include soya, maize, rice and cotton. However, the main staple crop of the Andes is the potato, and there are over a hundred different varieties found in the mountains.

Most farming is subsistence, with the food grown for personal consumption, but there is some commercial farming. Llamas have historically been used a lot in the Andes, as a form of transportation and to carry goods. Alpaca, a relative of the Llama, has been used to produce some of the finest cloth known to man, and is also produced in the Andes mountains.

Mining

The Andes Mountains contains a rich mix of minable materials that are both very valuable and very useful to man. When the Spanish conquered South America their prime objective was to prospect for gold. Potosi in Bolivia was one of Spain's principle mines and produced lots of silver. There exist large deposits of Coal, oil and natural gas, iron ore, gold, silver, tin, copper, phosphates and nitrates and Bauxite (for aluminium) within the Andes mountains. The Yanacocha gold mine in Peru is the largest gold mine in the world. It is an open cast mine and the rocks containing the gold are blasted with dynamite. The rock is then sprayed with toxic cyanide and the gold extracted from the resulting solution. This can contaminate water supplies. The nearby town of Cajamarca has grown from 30,000 when the mine started to 240,000 people in 2005.

Hydroelectric power

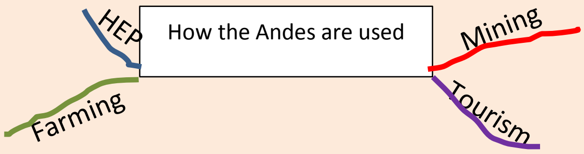
The deep valley and rivers of the Andes give it huge potential as a region to produce hydroelectric power. The narrow valleys are ideal to dam as it cuts costs, and the steep relief increases water velocities allowing electricity generation. Snow melt fuels most of the water provision, but this means that HEP production can be reduced to small amounts in winter. The Yuncan dam project dams the Puacartambo and Huachon rivers in northeast Peru, while the el Platinal project began construction in 2009.

Tourism

Tourism is a massive industry for Peru and the country has a lot to offer. In the East you can take part in Eco-tourism activities in the Amazon Basin, as found along the Madre De Dios River near to Puerto Maldonado. Peru has some breath taking scenery and a variety of activities, including the Inca Trail . The trail basically covers 50km of old pathways linking together old Inca settlements in the inhospitable mountains of the Andes. It is South America's best known trek and is one of only 23 World Heritage Sites (as deemed by UNESCO) to be classified as important both naturally and culturally. The rail is covered in 4 days and covers around 45km, and finishes with sunrise at the "Lost City of the Incas" at Machu Picchu. The trail is strictly controlled, and only 200 trekkers are allowed to start out on the trail every day.

ACTIVITIES 1.4

1. Condense the notes on land uses in the Andes on the previous pages into a simple mind map explaining how the Andes is used



2. Why are fold mountains difficult places to live?

3. How sustainable are the land uses of the Andes? JUSTIFY your answer.

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Volcanoes

Volcanoes are basically mountains that can explode with violent consequences. **Volcanoes are a geological landform created by the intrusion of magma into the earth's crust and by the eruption of that magma onto the Earth's surface through a vent**. There are many different types of volcano, and they are classified in different ways according to their type of eruption, the material ejected and their activity.

Volcanic activity

According to the activity of volcanoes, there are extinct, active, and dormant categories. Easily recognized volcanoes are active volcanoes, but dormant and extinct volcanoes are difficult and dangerous sometimes. The people living near known extinct and dormant volcanoes must always be on the lookout. Volcanoes can erupt at any time without warnings.

The constantly erupting volcanoes are active. The eruption is usually quiet but can sometimes be violent. Stromboli, which lies on an island near Italy, is a famous active volcano.

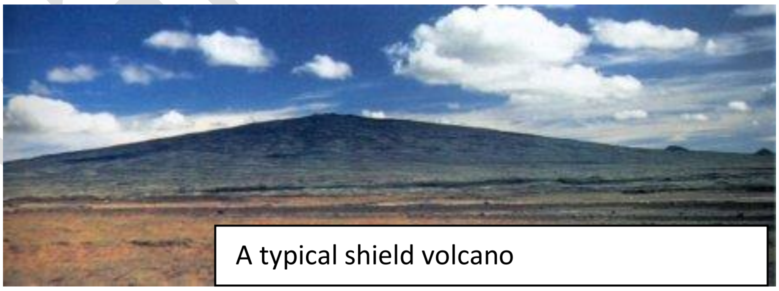
Intermittent volcanoes erupt at fairly regular time periods. Mount Asama and Mount Etna are some intermittent volcanoes.

Inactive volcanoes that have not erupted for an amount of time but can't be called extinct are dormant volcanoes. They can be called "sleeping" volcanoes.

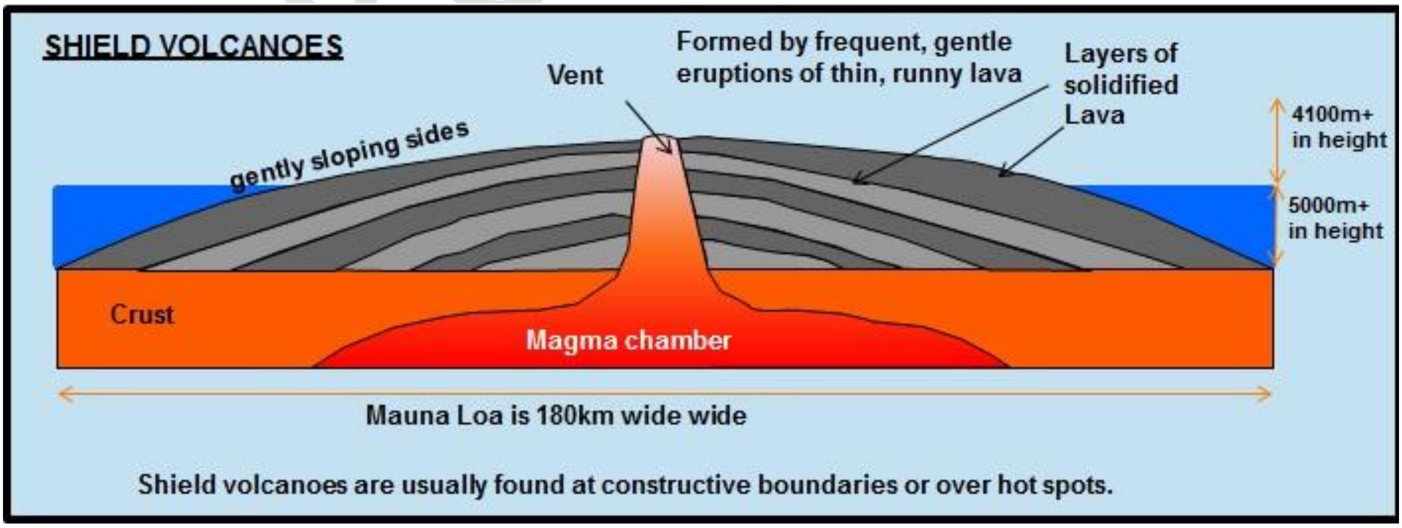
Inactive volcanoes which have not erupted since the beginning of recorded history are extinct volcanoes. They will never erupt again unless they are still dormant and have been mistaken for extinct volcanoes.

Types of volcano

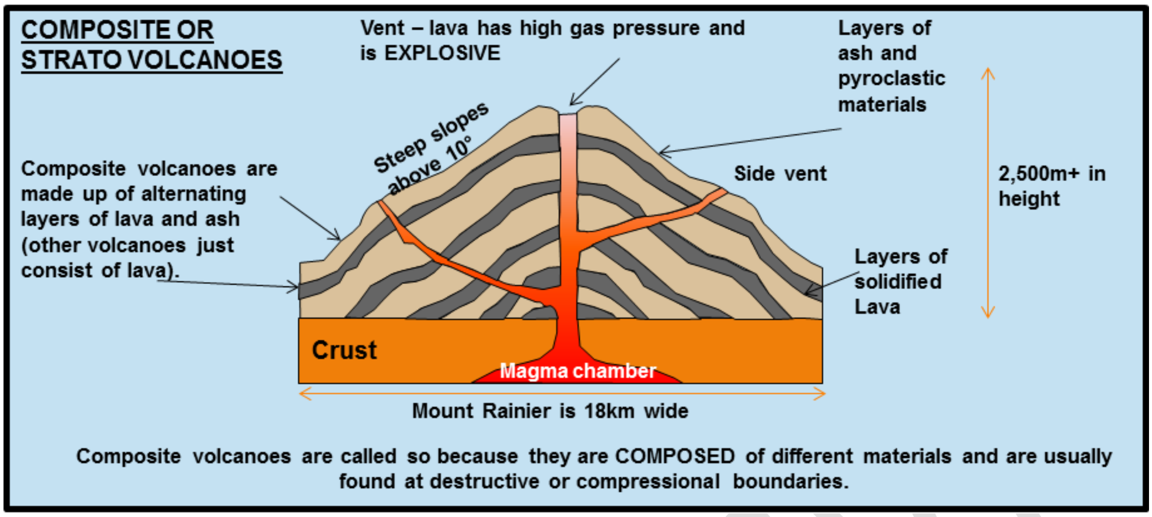
Shield volcanoes


A typical shield volcano

Hawaii is an example of a place where volcanoes extrude **huge quantities of basaltic lava that gradually build a wide mountain with a shield-like profile**. Their lava flows are generally very hot and very fluid, contributing to long flows. The largest lava shield on Earth, Mauna Loa, rises over 9,000 m from the ocean floor, is 120 km in diameter and forms part of the Big Island of Hawaii.



Strato volcanoes



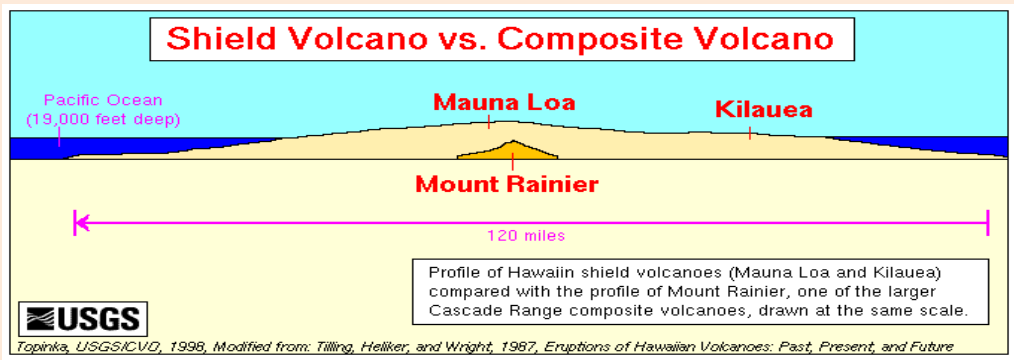
These are tall steep sided conical mountains composed of lava flows and other material in layers, these layers (strata) give rise to the name. Strato volcanoes are also known as composite volcanoes. Classic examples include Mt. Fuji in Japan, Mount Mayon in the Philippines, and Mount Vesuvius and Stromboli in Italy.

Volcano structure

Volcanoes are often made up of several layers of dust, ash, pyroclastic (blast) material and lava. The amount of each material depends upon the eruption history of the volcano. You can see a cross section of a volcano to the left, as you can see there is also a complex system of vents and faults along which volcanic material can travel. A vent is simply an opening through which eruptive material escapes, and volcanoes often have a central magma chamber.

ACTIVITIES 1.5

1. Compare and contrast the shapes of shield and composite (strato) volcanoes shown below



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2. Explain why strato and shield volcanoes differ______________________________

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3. List a range of hazards associated with volcanoes____________________________

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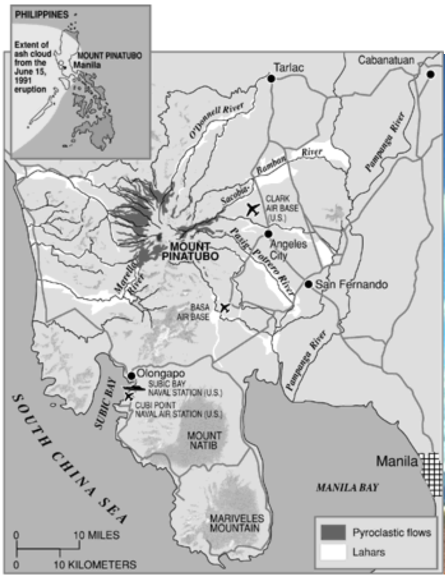
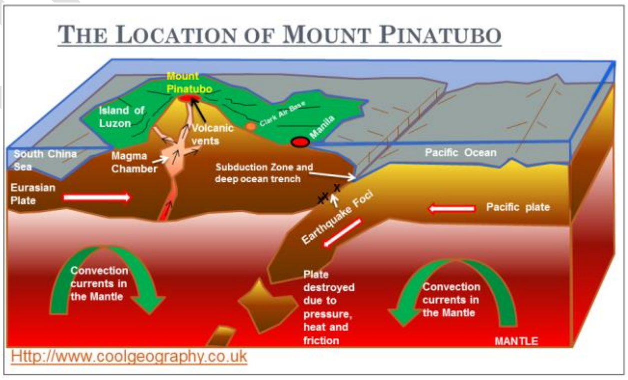
Mount Pinatubo - the impacts of a volcanic eruption in an LEDC

Background



Mount Pinatubo is on the Island of Luzon in the Philippines in South East Asia. It is located at the plate boundary between to the Eurasian and Philippine Plate. It is one of a chain of volcanoes known as the Luzon volcanic arc, which is the result of the Oceanic Philippine plate being subducted under the lighter Continental Eurasian plate.



The Volcano is slightly offset from the plate boundary as, when the Oceanic plate is subducted it is melted and forced away as molten magma by the high pressures exerted on it. It then resurfaces as the density of the molten magma becomes lower than that of the rock, and so it pushes it up through the small cracks and explodes out through a volcano.

It exploded in 1991 and had some catastrophic effects, both for the people of the Philippines and the USA air force at Clarke airbase.

Effects

Social Effects	Economic Effects	Environmental effects
847 People Killed - 300 from collapsing roofs, 100 from the mud flows known as lahars, the rest from disease in the evacuation centres including measles. 1.2million people lost homes and had to migrate to shanty towns in Manila Electricity went off, water was contaminated, road links were destroyed, and telephone links were cut 58,000people had to be evacuated from a 30km radius of the volcano	650,000 workers lost jobs $700 Million Damages Houses and bridges destroyed and needed replacing and Manila airport had to be closed Farmland destroyed by falling ash and pumice, unusable for years, the 1991 harvest was destroyed and 650,000 people lost their jobs	Volcanic ash is blown in all directions over hundreds of KMs, smothering fields and buildings. Heavy rainfall from Typhoon Yunga causes buildings to collapse. Fast flowing volcanic mudflows (lahars) caused severe river bank erosion, undercut bridges etc. Global cooling caused by ash in the atmosphere of 0.5°C

Prediction, Prevention, Aid and Monitoring

	Prediction	Prevention	Preparation
What they actually did	75,000 people were evacuated due to accurate predictions. There was no monitoring until the 3rd of April but seismometers were put into place. The United States Geological Service helped to predict the disaster	75,000 people evacuated up to a radius of 30km. USA air force helicopters helped. Alert systems put into place to warn of eruption. Government Shelters.	Evacuation camps built for refugees. Warning sign like gas and steam looked for. Long and short term aid organized especially from the Red Cross and the United States
What they could have done	Set up permanent monitoring points or use satellite images to look upon volcano site for changes in land surface.	Placed strategies for long term aid and disease control in evacuations prepared for.	Storage of medical supplies food and water in preparation for disaster.

ACTIVITIES 1.6

1. Draw a sketch map of the location of Mount Pinatubo including the Island of Luzon, the Eurasian Plate and the Philippines plate.

2. Rank the Impacts of Mount Pinatubo from 1 (worst impact) to 12 (least severe impact)

	Rank
847 People Killed - 300 from collapsing roofs , 100 from the mud flows known as lahars, the rest from disease in the evacuation centres including measles.	
1.2million people lost homes and had to migrate to shanty towns in Manila	
Electricity went off, water was contaminated, road links were destroyed, and telephone links were cut	
58,000people had to be evacuated from a 30km radius of the volcano	
650,000 workers lost jobs	
$700 Million Damages	
Houses and bridges destroyed and needed replacing and Manila airport had to be closed	
Farmland destroyed by falling ash and pumice, unusable for years, the 1991 harvest was destroyed and 650,000 people lost their jobs	
Volcanic ash is blown in all directions over hundreds of KMs, smothering fields and buildings.	
Heavy rainfall from Typhoon Yunga causes buildings to collapse.	
Fast flowing volcanic mudflows (lahars) cause severe river bank erosion, undercut bridges etc.	
Global cooling caused by ash in the atmosphere of 0.5°C	

3. Explain your ranking:____

4. Was Mount Pinatubo well managed? Justify your response____________________________

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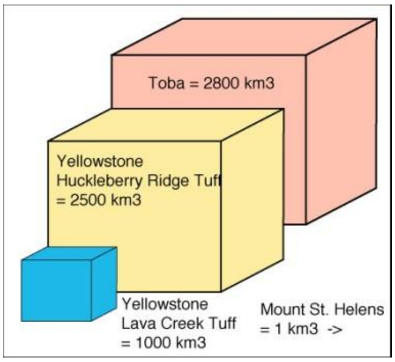
Supervolcanoes

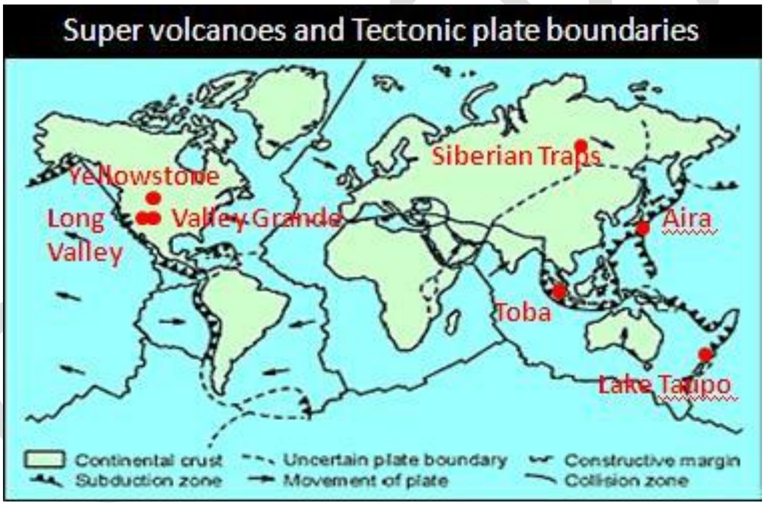
The Toba Super Eruption



The last supervolcano to erupt was 74000 years ago in Indonesia, when a gigantic volcanic eruption shook the earth. The ash was thrown out 3000km, created global cooling and created a crater larger than the city of London. This super eruption created Lake Toba, 100km long and 50km wide. A supervolcano such as Toba could reduce temperatures globally by 5 degrees Celsius – enough to spark an ice age and ruin agriculture globally!

Just a few thousand people lived on earth at the time – but what would happen if this struck the USA? A super eruption could affect whole world and badly affect the USA. The USA has a supervolcano in the shape of Yellowstone National Park .

Massive lake Toba, in the caldera of a super volcano

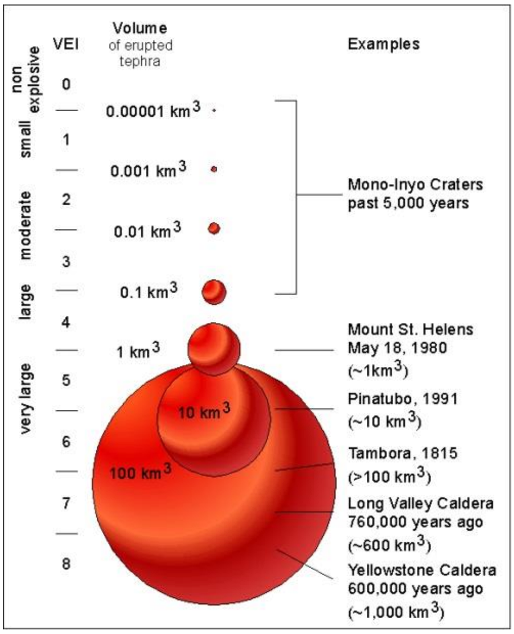


What are supervolcanoes?

Supervolcanoes are hard to spot and need a minimum of 1,000km^3 of eruptible material. Whereas, regular composite volcanoes (such as Mount Pinatubo) have a cone shape, supervolcanoes are depressions in the ground. The Calderas are so large they can sometimes only be spotted from space and have been identified in Indonesia, in New Zealand, in South America and an extinct one in Glen Coe in England. Yellowstone is still active, and is America's most famous and popular National Parks. Over 3 million people visit the park every year, but do they know they are visiting a time bomb?

Supervolcanoes are not mountains – they form DEPRESSIONS within the Earth's crust. They begin with a column of magma rising through a vent into the Earth's crust. The magma gets stuck and pools, melting the rock around for thousands of years. Over thousands of years the pressure builds up and when the eruption eventually happens it drains the magma lake and the land above collapse down over, creating a caldera.

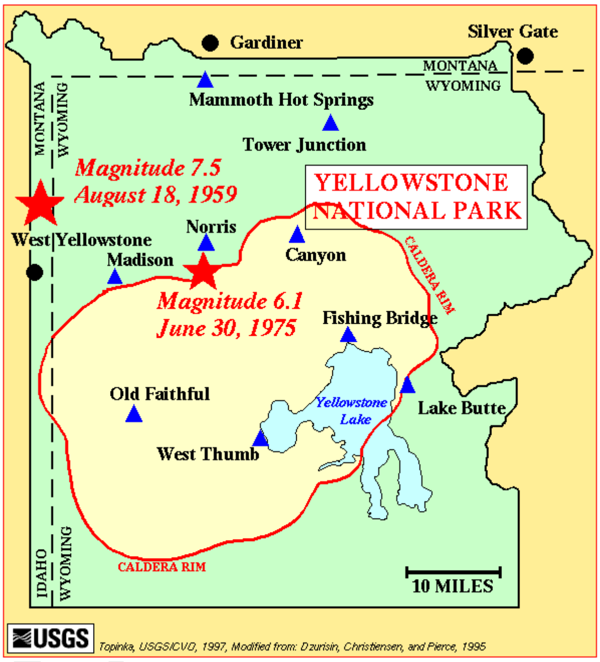
Supervolcanoes are eruptions and explosions of catastrophic proportions, on the Volcano Explosivity Index (VEI) supervolcanoes are an 8 on a scale that runs from 1 to 8. Each leap up the scale represents an increase of explosive scale of 10 times the power. Mount St Helens was VEI 5!



Yellowstone Supervolcano

The volcano at Yellowstone is close to 100km across, and Yellowstone National park has hot springs and geysers and is known to be geothermal.

What exists beneath Yellowstone is a hot spot, where magma moves upwards in the Mantle, hits the base of the earth's crust and melts it creating a huge chamber of magma. The hot spot is static but the Earth's crust moves over it. Therefore there have been many craters across the US caused by this hot spot. 2 million years ago this hotspot settled under Yellowstone. The mountain range around Yellowstone is interrupted by the 2.1million year's caldera explosion – this swallowed 80 km worth of mountains. Since then, there have been 2 more explosions, 1.3million years ago and 640000 years ago – a cycle of 600,000 to 700,000 years.



Scientists discovered that the magma chamber is 80km long, 40km wide and 8km deep.

If Yellowstone erupts it will be disastrous for the whole world. The magma will push the dome up, earthquakes will occur, allowing fissures to crack the surface allowing pressure release, lava to escape and columns of ash to be ejected 10s of kilometres into the air, pyroclastic flows would kill thousands of people. The ash would cover the Great Plains stopping grain production, economic activity in the US would be affected, and global climate would be changed, stopping the growing season.

ACTIVITIES 1.7

1. List 4 characteristic features of a supervolcano
   a)
   b)
   c)
   d)
2. Describe where supervolcanoes are located using the map on the previous page.______________

3. Outline the potential global and national impacts of a super volcanic eruption at Yellowstone National Park.

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Earthquakes

Earthquakes are vibrations in the Earth's crust that cause shaking at the surface. They are highly unpredictable and often occur suddenly without warning, mainly on the plate margins. We do know where most earthquakes will occur, and they tend to coincide with destructive, conservative, collisional and constructive plate margins.

Reasons for Earthquakes happening

1. Earthquakes occur because stresses build up between the plates as one plate passes another.
2. As the plates move past one another they don't do so smoothly, rather, they snag and grind, allowing energy to build up.
3. When the plates eventually move again this energy is released as shock or seismic waves through the Earth's crust.
4. **The point at which this slippage occurs is called the FOCUS, whilst the point on the ground surface above the earthquake FOCUS is called the EPICENTRE.**
5. Seismic shock waves will go radially outwards from these points and their energy will reduce with distance.

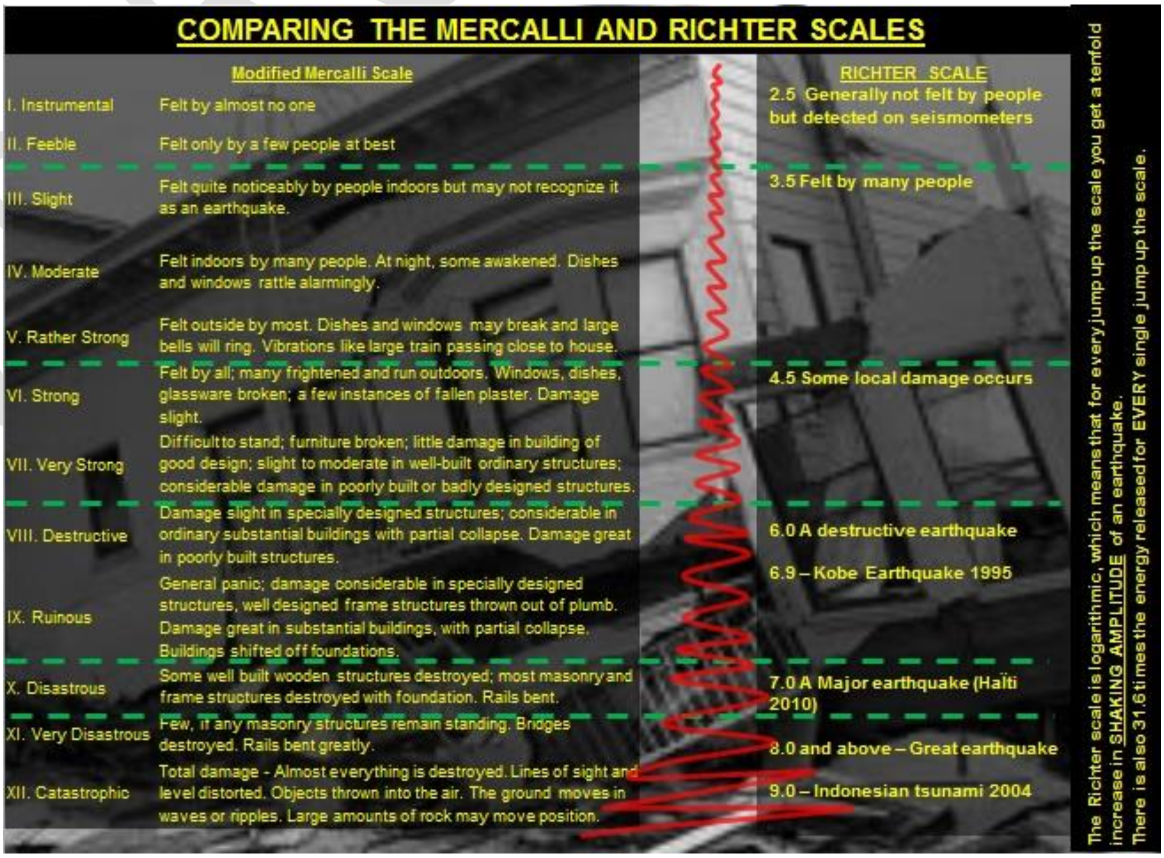
Earthquakes can also occur at constructive plate margins. Here, the earthquake is the result of magmas forcing its way between the plates, causing the earth to tremble. Collisional margins, where continental crust meets continental crust, can also have earthquakes as a result of the pressures generated by collision.

Earthquake waves

The first waves in an earthquake will shake the ground UP then Down in a longitudinal movement. These waves are called P or PRIMARY waves. They travel fastest, and can also cause back and forth movement. These waves are relatively weak and cause the surface to move in a back and forth motion. The next waves to arrive are **S or Secondary waves, which travel slower through the crust. These waves cause the crust to move from side to side at right angles to the outward motion of the main wave.**

How Earthquakes are measured

Earthquakes can be measured using 2 scales -the Richter scale or the Mercalli scale. **The Mercalli scale measures the effects of the earthquake and runs from 1 to 12.** The higher up the scale the more damage is experienced by people and building structures. **The Richter scale is different in that it measures the energy of an earthquake**. The scale is logarithmic, which means that for every jump up the scale you



get a tenfold increase in power of an earthquake. Therefore a magnitude 6 is 10 times more powerful than a magnitude 5, and 100 times more powerful than a magnitude 4. The higher the magnitude of an earthquake the less frequent its occurrence. The largest ever recorded was in Valvidia in Chile in 1960 and recorded 9.5 on the scale.

Reasons why Earthquake damage varies

Population Density - the more densely populated an area the more potential there is for loss of life and damage to property. One of the reasons for the huge extent of the damage caused by the earthquake which hit Kobe was the fact that the area is very densely populated.

Earthquake depth - generally, the deeper the focus of the earthquake in the Earth's crust the less damage that is caused. This is because the waves lose energy as they travel through the crust, so by the time they reach the surface the damage can be minimised.

Building design - Buildings can be designed to withstand the shaking of the earth and to limit the loss of life and damage caused. The Transamerica pyramid has a shape that can withstand seismic waves and withstood the 1989 Loma Prieta earthquake which struck San Francisco. Other strategies include rolling weights on the roofs of buildings, shatterproof glass to prevent scattering glass during a quake, emergency shutters for glass, gas shut off valves and identification numbers on buildings.

Earthquake strength - the stronger the earthquake the more damage would be caused. This is explained in how we measure earthquakes above.

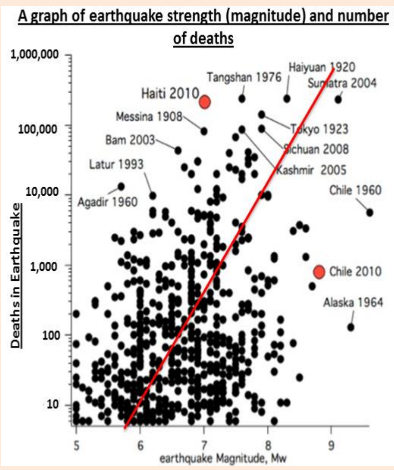
Geology - the rock type of the area in which the earthquake occurs. If the area is solid rock there is generally less damage than on sands and clays. On clays, liquefaction can occur, where water penetrates between the clay particles creating a quick sand like substance into which buildings can sink.

ACTIVITIES 1.8

1. Explain how the following factors affect the level of earthquake damage

Earthquake strength	
Geology	
Earthquake depth	
Population density	
Building design	

2. Describe and explain the pattern on the graph below.______________________________



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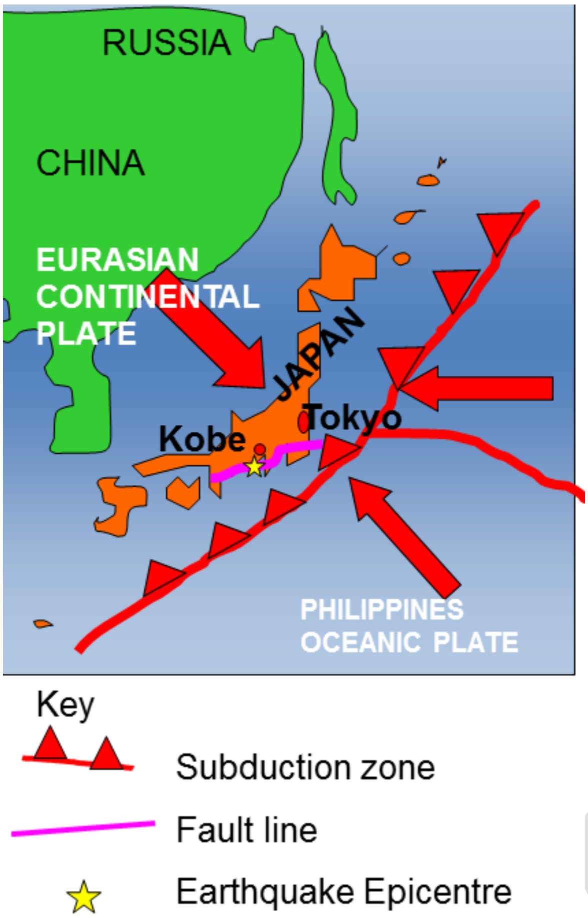
The Kobe Earthquake – an earthquake in an MEDC



Kobe is located in the south east of Japan, near a destructive plate margin. It is a megacity and has one of the largest container ports in the World. Although further from a plate margin than most of the cities in Japan, Kobe is still found on a fault line.

The earthquake that hit Kobe during the winter of 1995 measured 7.2 on the Richter scale. At this plate margin, the Pacific plate is being pushed under the Eurasian plate, stresses build up and when they are released the Earth shakes. This is known as an earthquake happening along a subduction zone. The focus was only 16km below the crust and this happened on the 17th Jan 1995 at 5.46am. 10 million people live in this area.

Effects

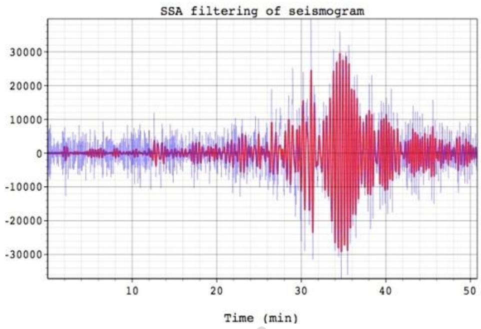
The effects of this earthquake were catastrophic for an MEDC. Despite some buildings having been made earthquake proof during recent years many of the older buildings simply toppled over or collapsed. A lot of the traditional wooden buildings survived the earthquake but burnt down in fires caused by broken gas and electricity lines. Other effects included;

- More than 5000 died in the quake
- 300,000 were made home less
- More than 102,000 buildings were destroyed in Kobe, especially the older wooden buildings.
- Estimated cost to rebuild the basics = £100 billion.
- The worst affected area was in the central part of Kobe including the main docks and port area. This area is built on soft and easily moved rocks, especially the port itself which is built on reclaimed ground. Here the ground actually liquefied and acted like thick soup, allowing buildings to topple sideways.
- Emergency aid for the city needed to use damaged roads but many of them were destroyed during the earthquake.
- Raised motorways collapsed during the shaking. Other roads were affected, limiting rescue attempts.
- Many small roads were closed by fallen debris from buildings, or cracks and bumps caused by the ground moving.
- The earthquake occurred in the morning when people were cooking breakfast, causing over 300 fires, which took over 2 days to put out.

Responses to the quake

Water, electricity, gas, telephone services were fully working by July 1995 and the railways were back in service by August 1995

A year after the earthquake, 80% of the port was working but the Hanshin Expressway was still closed.



By January 1999, 134,000 housing units had been constructed but some people still had to live in temporary accommodation.

New laws were passed to make buildings and transport structures even more earthquake proof.

More instruments were installed in the area to monitor earthquake movements.

Most new buildings and roads have, in the last 20 years, been designed to be earthquake proof, schools and factories have regular earthquake drills, etc. Despite this, many older buildings still collapsed or caught fire. This led to many blocked roads and massive problems of homelessness.

Electricity and water supplies were badly damaged over large areas. This meant no power for heating, lights, cooking, etc. Clean, fresh water was in short supply until April 1995. The government and city authorities were criticised for being slow to rescue people and for refusing offers of help from other countries.

Many people had to sleep in cars or tents in cold winter conditions

Solutions;

Preparation – A lot of the buildings in Kobe and Japan made after the 1960s are earthquake proof (necessary by law) with counterweights on the roofs and cross steel frames. Many of the damaged buildings in Kobe were built before this period and were made of wood, which caught fire. People are educated on earthquake preparation in Japan.

Prediction – Japan has the world's most comprehensive prediction programme with thousands of seismometers and monitoring stations in Japan designed to give warning. Kobe hadn't had an earthquake in 400years and had less prediction equipment than other areas of Japan.

Aid – The Japanese rejected international offers of aid and dealt with the earthquake itself. All of the homeless people were dealt with reasonably quickly and the city recovered thanks to government money.

ACTIVITIES 1.9

Complete the case study table to summarise the ESSENTIAL information about this earthquake;

Background (where, when, size)		
Causes		
Effects	Short term	
	Long term	
Responses	Individuals	
	Agencies	
	Governments	

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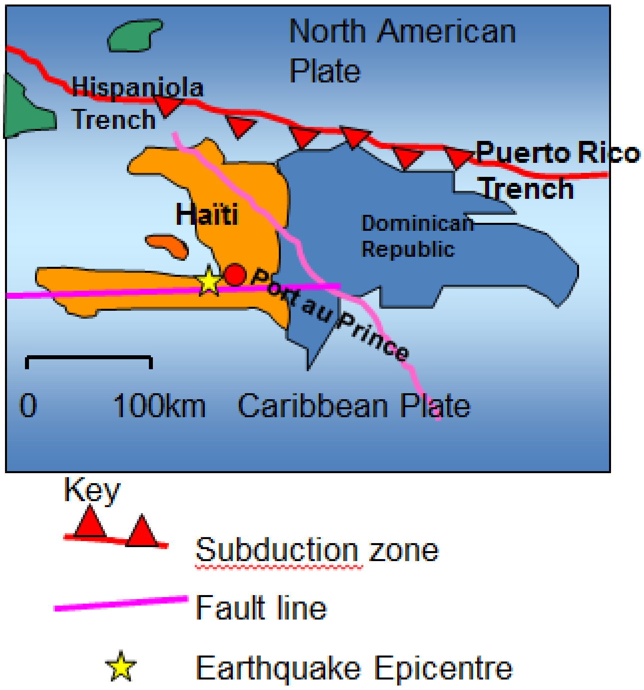


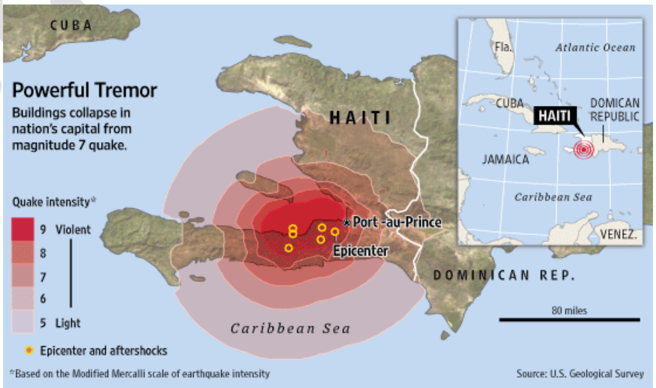
Haiti is the poorest country in the Western Hemisphere, its GDP is only $1,200 per person, 207th in the world, and its HDI is incredibly low at 0.404, 145th in the world, and 80 % of its 9.7 Million people live below the poverty line.

Port Au Prince, the capital, is on a fault line running off the Puerto Rico Trench, where the North American Plate is sliding under the Caribbean plate. There were many aftershocks after the main event. **The earthquake occurred on January 12th 2010, the epicentre was centred just 10 miles southwest of the capital city, Port au Prince and the quake was shallow—only about 10-15 kilometres below the land's surface.** The event measured 7.0 on the Richter Magnitude scale.

There were many impacts including;

•316,000 people died and more than a million people were made homeless, even in 2011 people remained in make shift temporary homes. Large parts of this impoverished nation were damaged, most importantly the capital Port Au Prince, where shanty towns and even the presidential palace crumbled to dust. 3 million people in total were affected. Few of the Buildings in Haiti were built with earthquakes in mind, contributing to their collapse

•The government of Haiti also estimated that 250,000 residences and 30,000 commercial buildings had collapsed or were severely damaged. The port, other major roads and communications link were damaged beyond repair and needed replacing. The clothing industry, which accounts for two-thirds of Haiti's exports, reported structural damage at manufacturing facilities. It is estimated the 1 in 5 jobs were lost as a result of the quake



•Rubble from collapsed buildings blocked roads and rail links.

• The port was destroyed

• Sea levels in local areas changed, with some parts of the land sinking below the sea

• The roads were littered with cracks and fault lines

Short term responses

Many countries responded to appeals for aid, pledging funds and dispatching rescue and medical teams, engineers and support personnel.

Communication systems, air, land, and sea transport facilities, hospitals, and electrical networks had been damaged by the earthquake, which slowed rescue and aid efforts.

There was much confusion over who was in charge, air traffic congestion, and problems with prioritisation of flights further complicated early relief work.

Port-au-Prince's morgues were quickly overwhelmed with many tens of thousands of bodies having to be buried in mass graves.

As rescues tailed off, supplies, medical care and sanitation became priorities.

Delays in aid distribution led to angry appeals from aid workers and survivors, and looting and sporadic violence were observed.

Long term recovery:

- The EU gave $330 million and the World Bank waived the countries debt repayments for 5 years.
- The Senegalese offered land in Senegal to any Haitians who wanted it!
- 6 months after the quake, 98% of the rubble remained uncleared, some still blocking vital access roads.
- The number of people in relief camps of tents and tarps since the quake was 1.6 million, and almost no transitional housing had been built. Most of the camps had no electricity, running water, or sewage disposal, and the tents were beginning to fall apart.
- Between 23 major charities, $1.1 billion had been collected for Haiti for relief efforts, but only two percent of the money had been released
- One year after the earthquake 1 million people remained displaced
- The Dominican Republic which neighbours Haiti offered support and accepted some refugees.
- Medicines San Frontiers, a charity, tried to help casualties whilst the USA took charge of trying to coordinate Aid distribution.

ACTIVITIES 1.11

1. Describe the location of the Haïti earthquake using the map on the previous page____________________
   ____
   ____
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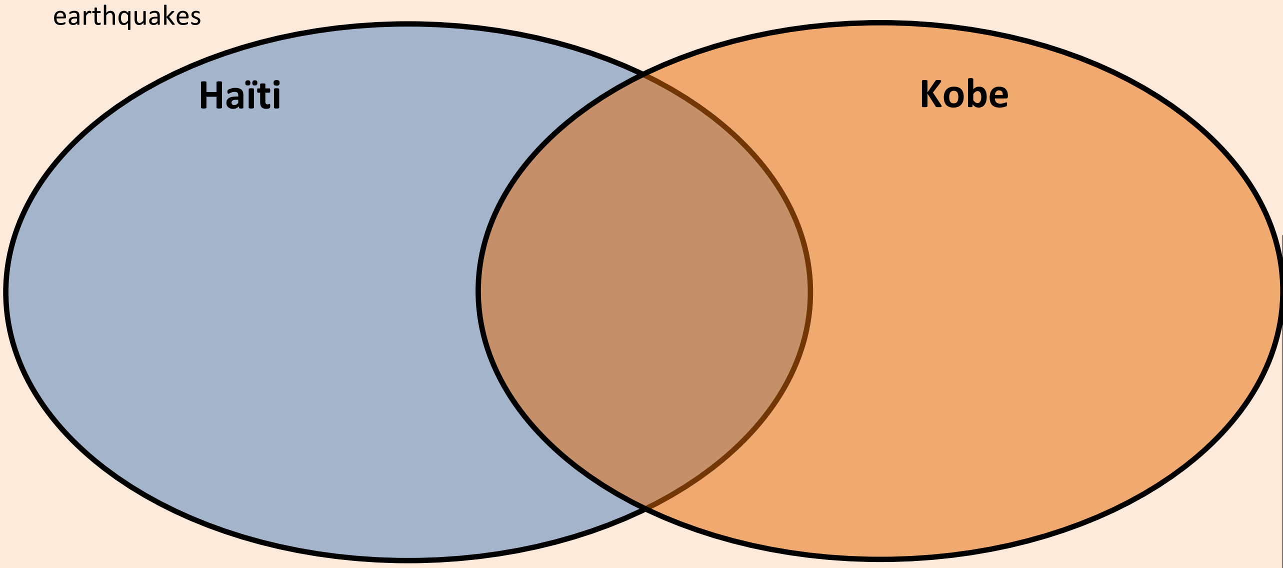
   ____
2. Complete the Venn diagram below to compare the similarities and differences between the Haïti and Kobe earthquakes



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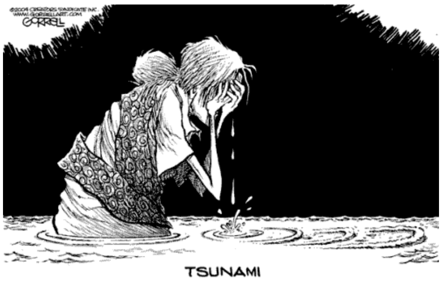
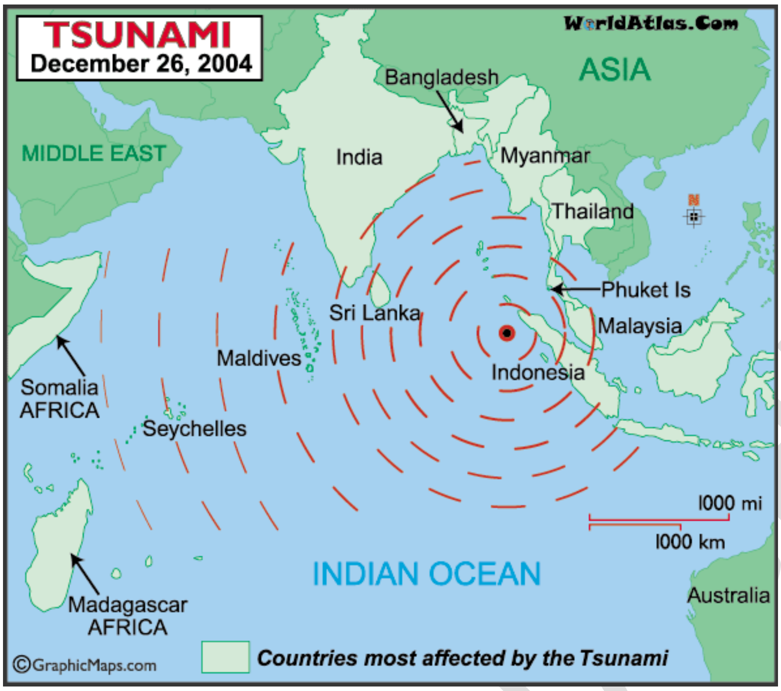
Tsunamis - an underwater Earthquake hazard

Tsunamis are also called seismic sea waves. Whereas most waves that we experience day to day are created by both the gravitational pull of the moon on the sea and wind acting upon the sea, tsunamis have other causes. **They can be created by landslides, underwater volcanoes and more commonly underwater earthquakes.** The Boxing Day tsunami of 2004 in the Indian Ocean was created by an underwater earthquake.



The Tsunami of December 26th 2004 killed over 220,000 people. This was an enormous disaster of which most people were completely oblivious to on that Boxing Day morning.



Why the Tsunami happened

Just after dawn on the Sundra trench a massive earthquake occurred on the ocean floor. The Indo-Australian plate is being subducted under the Eurasian plate at the Sundra Trench, and has been doing this for 20million years. This zone has stick slip frictional properties, which means that it drags the upper plate down with it, deforming the upper plate. Eventually the stress becomes too much and the upper plate snaps back – causing the earthquake.

When an earthquake occurs under the ocean its seismic energy can go through the Earth's crust or as shockwaves through the ocean water. The earthquake occurred close to the surface, only 30km deep, and caused tsunami initiation. The movement of the sea bed upwards displaces billions of tonnes of water above it, some sea floor falls and water rushes in to replace it. The uplifted water collapses and rushes out radially outwards at a thousand km per hour.

A timeline of destruction

20 minutes before the water arrives Banda Aceh feels the force of the earthquake and buildings collapse.

10 minutes after the earthquake in Sumatra (Aceh province) the wave is approaching at 600miles an hour,

15minutes after the quake Northern Sumatra becomes the first place to be hit. It caused utter devastation. Banda Aceh was completely destroyed, with barely any buildings left standing. The height of the wave here was colossal, higher than the coconut trees. Ships were thrown up onto the land, and the cement works were destroyed. ¾ of the tsunamis victims died in Sumatra.

30 minutes after the quake, 7000 people are killed in the Nicobar Islands

1 hour after the earthquake in Thailand, people still do not know that people have died in Indonesia. People climbed upon the tops of hotels to survive. The exposed bays in Phuket which faced the wave bore the brunt of the wave, whereas bays which faced away got of relatively lightly. Buildings and decking were ripped up. Phuket was hit by a

second wave 15 minutes later, which was even bigger than the first wave. Multiple waves in Tsunamis are normal. The second wave rolled around the whole of Kamala bay. As the water retreats back out to sea it pulled cars, debris, fishing boats and people back out with it.

2 hours after the earthquake, the wave reaches Sri Lanka. A train was running along the coast from Colombo to Galle. The train was hit by the wave of water, and split the train up. The second wave arrived soon after, killing most of the people who had survived the first wave on the train. 1500 people died on the train, 45,000 people died in India and Sri Lanka.

3 ¾ hours after the quake, the Maldives are only slightly effected.

7 hours after the quake, East Africa is next affected. News is finally getting to communities and in Kenya there was only one fatality as people were warned. The wave dissipates throughout the whole ocean across the globe.

There were no water level sensors, no warning systems and no disaster plans. This all contributed to the high death toll.

Overall effects;

- By the end of the day of the 2004 Indian Ocean tsunami, it had already killed 150,000 people. The final death toll was 283,000.
- The Indian Ocean tsunami travelled as far as 3,000 miles to Africa and still arrived with sufficient force to kill people and destroy property.
- Many people in Indonesian reported that they saw animals fleeing for high ground minutes before the tsunami arrived – very few animal bodies were found afterward.
- The risk of famine and epidemic diseases was extremely high immediately following the tsunami – bodies rotting in the tropical heat contaminated food and water sources.
- 1.7 million people were displaced

Responses		
	SHORT TERM RESPONSES	LONGTERM RESPONSES
INDIVIDUALS	Most individuals ran (Fled) for their lives. They climbed buildings, hills and trees. Some people Froze, they walked to the sea side to watch the wave approach and could not escape once they realised what they faced.	Many people have re-established buildings and businesses in the affected regions, but many people permanently migrated from the area.
GOVERNMENTS	The governments of the affected countries reacted reasonably quickly but were reliant in many cases on OUTSIDE AID due to the magnitude of the disaster and the lower level of economic development of the places affected. India sent naval ships to affected areas, whilst Thailand, Indonesia responded but slowly, given the extent of the disaster. The World Health Organization warned that the number of deaths from preventable diseases such as cholera and typhoid could rival the death toll from the disaster itself. The USGS managed to get a warning to Africa which saved lives	Country governments helped to rebuild whole community towns, including in Indonesia in Aceh province An early warning system for Tsunami has now been put in place in the Indian Ocean, through co-operation from many governments The DEC Earthquake/Tsunami disaster appeal fund stood at £32 million, up £7 million in one night from the 31st of December. Countries sent aid teams immediately while MEDCs such as the UK sent dog teams, forensic experts and equipment to help identify bodies and clean up after the Tsunami
NON - GOVERNMENT ORGANISATIONS	Action Aid raised £13million and immediately sent food aid.	In the long run Action Aid offered Psychological counselling, paid for housing, paid for boats with motors for fishing communities, rebuilt schools and community centres, in an attempt to rebuild areas.

ACTIVITIES 1.12

1. Describe the changes to the environment affected by the 2004 Asian Tsunami below;______________

January 2, 2005

April 12, 2004

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2. Complete the case study table to summarise the ESSENTIAL information about this earthquake;

Background (where, when, size)		
Causes		
Effects	Short term	
	Long term	
Responses	Individuals	
	Agencies	
	Governments	

Exam style Questions

1. Study the map below which shows the location of earthquakes, their magnitude and the number of deaths.

a) Describe the pattern shown on the map above.
b) Explain the pattern shown on the map above.

2. Study the photograph below which shows damage from the Christchurch earthquake in New Zealand.

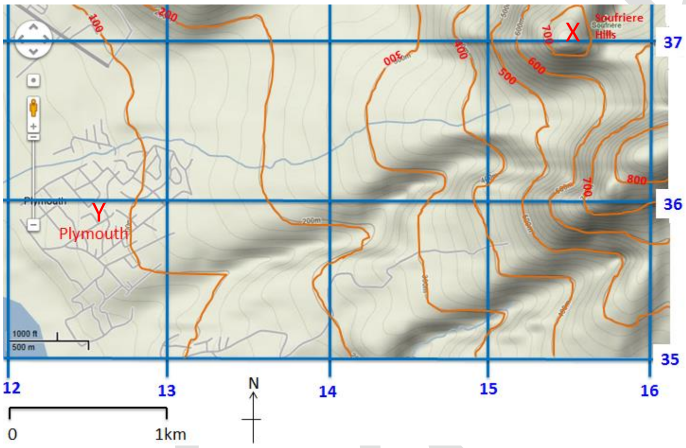
a) Describe the damage caused in the photograph.
b) Explain how the damage in the photograph might affect the short term recovery in the area.

3. People respond to hazards in different ways. Choose a volcano or an earthquake you have studied in an LEDC.
   Describe the measures to predict and to take precautions against your chosen hazard
   and
   explain the short term responses to your chosen hazard**.**

4. *Choose a volcanic eruption you have studied.*
   Describe the aid given to people affected by the eruption
   and
   *Explain the long term recovery of the area affected by the volcanic eruption**.***

5. People respond to Tsunami in different ways. Choose a Tsunami you have studied. Explain how people responded in the short term and the long term.

6. Study the map below of Montserrat, which suffered a volcanic eruption from the Soufriere Hills in 1995.



Using the map above;

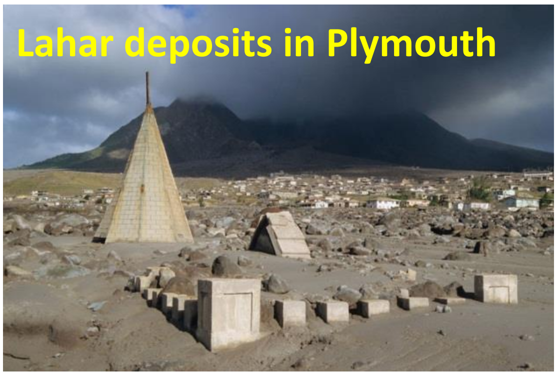
a) Give the height of the land at;
- 154 370
- 136 365

b) What happens to height of the land as you move directly East from Plymouth?

c) How far is it from Soufriere Hills (X) to the centre of Plymouth (Y)?

d) What compass direction is it from Soufriere Hills (X) to the centre of Plymouth (Y)?

e) Describe the shape of the volcano at Soufriere Hills (X) using map evidence

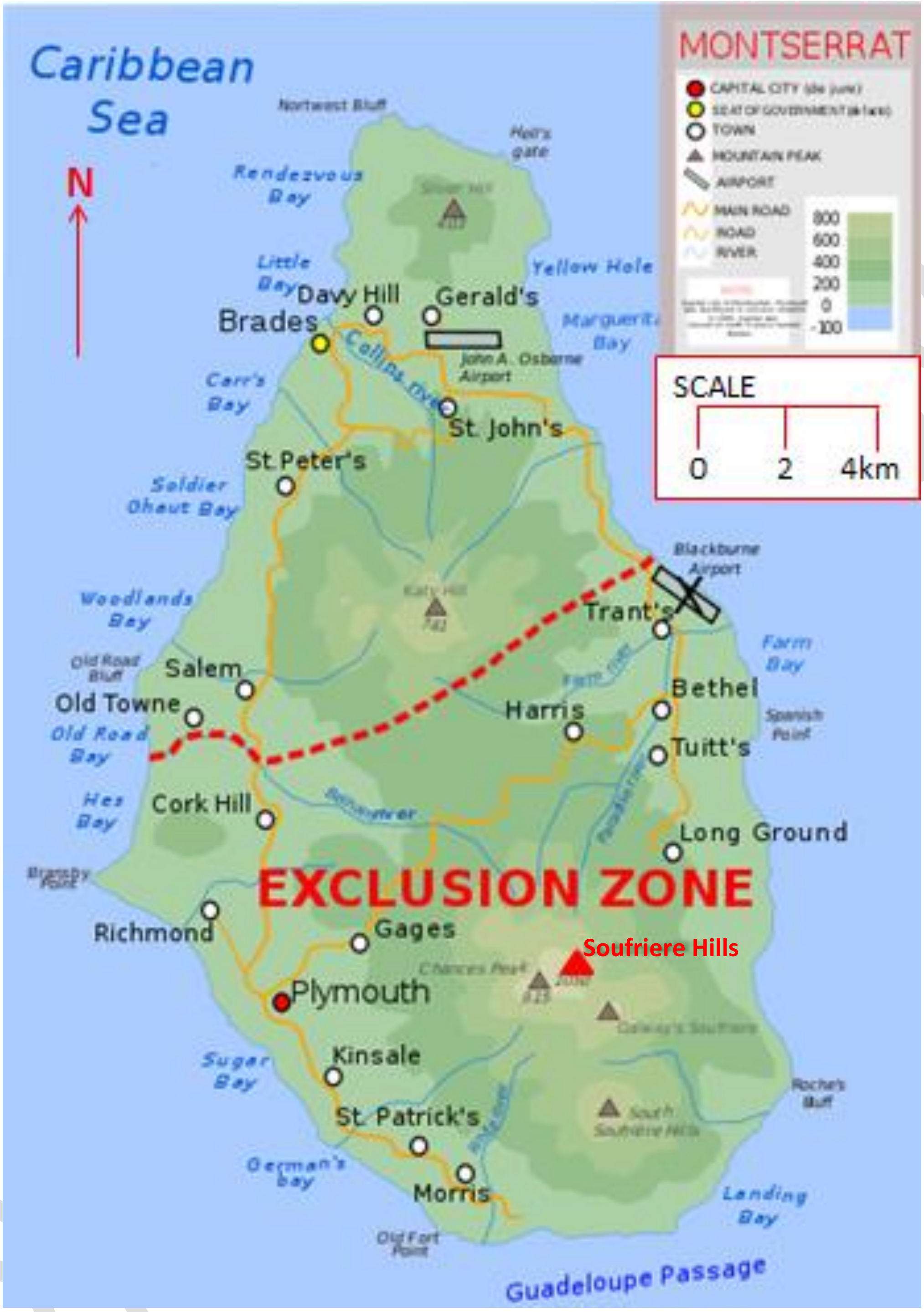


f) Look at the photograph opposite, what effects have Lahars (volcanic mudflows) had on Plymouth?

g) Which direction was the camera pointing when the photograph was taken?

h) Using map evidence, explain why Plymouth suffered so badly from Lahars (volcanic mudflows) after the eruption of the Volcano in the Soufriere Hills (X).

7) Study the map below



a) How far is it from the volcano at Soufriere Hills to Blackburne airport?
b) What compass direction is it from the volcano at Soufriere Hills to Blackburne airport?
c) Using map evidence explain why Blackburne airport suffered from pyroclastic flows when the volcano erupted in 1995.
d) Approximately how big is the exclusion zone?

Glossary

Aid	Money, food, training and technology given by richer countries to poorer countries
Anticline	An upfold within sediments found in layers of rock that make up fold mountains
Birdcage frame	A steel cage that stops buildings from collapsing
Bubbling mud	Where mud is melted and mixed with water by geothermal heat
Caldera	A huge depression in the Earth's crust, surrounded by a large ridge, left by the collapse of an exploded super volcano
Composite volcano	tall, cone-shaped volcano in which layers of lava alternate with layers of ash
Conservative plate margin	Where one plate slides past the other sideways
Constructive Plate margin	Where the two plates move apart making new crust
Continental crust	granitic part of the Earth's crust that makes up the continents. Continental crust is also called sial because it consists largely of silica and aluminum and averages about 40km thick
Convection current	the movement of magma in the mantle caused by heating of the material
Crater	A bowl shaped opening at the top of a composite volcano
Crust	the outer layer of the Earth
Destructive plate margin	Where one plate sinks under another, destroying the old crust
Earthquake	shaking and vibration at the surface of the earth resulting from underground movement along a fault plane or from volcanic activity
Epicentre	the point on the Earth's surface directly above the focus of an earthquake
Evacuation	Where people are moved from zones of risk
Fissures	Large cracks in the earth's crust that allow magma to escape
Focus	The point WITHIN the Earth's crust where an earthquake starts
Fold mountains	these are mountains formed as the plates move together and folds are formed as the the layers are squeezed horizontally.
Geothermal	of or relating to the heat in the interior of the earth
Geyser	a spring that discharges hot water and steam
HEP	Hydroelectric power - as found in the deep valleys of many fold mountains
Hot spot	an area where magma from deep within the mantle melts through the crust above it
Inner Core	a dense sphere of solid iron and nickel at the center of Earth
Lahar	A volcanic mud flow
Long term response	Actions that occur in the months and years after a hazardous event
Longitudinal wave (P - wave)	Where the land is shaken up and down caused by the first wave caused by an earthquake
Magma Chamber	A cavity within a volcano where molten material is stored
Mantle	the layer of the earth between the crust and the core
Mercalli Scale	a scale that rates earthquakes according to their intensity and how much damage they cause at a particular place
Monitoring	When instruments are used to monitor a hazard
Natural Hazard	Any natural event that has the capacity to kill people and damage their possessions
Oceanic crust	thin, more dense than continental crust, subducting crust
Ocean ridge	created at a divergent boundary where the ocean plates spread apart. Magma rises out to form underwater mountains.
Ocean Trench	deep valley in the ocean floor that forms along a subduction zone
Plate Margin	Any point on the Earth's surface where the two plates meet
Prediction	Methods such as radars, tilt meters and sulphur gas meters used to try to tell when a volcano will erupt or an earthquake will happen
Preparation	Organising activties that give people education so they know what to do in a hazard
Prevention	Any way of stopping a hazard happening, not currently possible for earthquakes and volcanoes
Primary Impact	The immediate impacts of a volcanic eruption
Protection	Constructing buildings and infrastructure that are safe during hazards
Pyroclastic flow	an avalanche of glowing rocks flowing on a cushion of hot gases
Richter scale	a scale that rates an earthquake's magnitude based on the size of its seismic waves
Satellite	A camera up in space that allows humans to monitor the Earth's surface
Secondary Impact	After effects or indirect impacts of a hazard - e.g. outbreaks of disease following an eruption
Seismograph	a measuring instrument for detecting and measuring the intensity and direction and duration of

	movements of the ground (as an earthquake)
Seismometer	Instrument used to measure horizontal or vertical motion during an earthquake.
Shield Volcano	a wide gentle sloping volcano made of layers of lava and formed by quiet eruptions.
Shock waves	Earthquake energy
Short term response	How people react as a disaster happens and the immediate aftermath
Subduction	Where one plate is pushed underneath another plate
Subsistence farming	Where farmers grow enough to feed themselves with little surplus for sale in the Andes
Supervolcano	A volcano that erupts at least 1,000km cubed of material
Syncline	A downfold within bedded sediments
Transverse wave (S - wave)	Where the land is shaken from side to side
Tsunami	a seismic sea wave usually caused by an underwater earthquake
Vent	The opening of a volcano at the Earth's surface