Topic: Living with Tectonic Hazards- Risk or opportunity?

Gateway 2: What landforms and associated tectonic phenomena are found at plate boundaries?

Geographical concepts		
• Tensional force • Compression force • Folding • Fold mountains • Rift valley • Block mountain	• Volcano • Pacific Ring of fire • Shield volcano • Stratovolcano • Composite volcano • Crater • Vent • Magma Chamber • Magma • Lava • Viscosity • Geothermal energy	• Earthquake • Focus • Epicentre • Richter scale • Aftershocks • Tsunami • Vulcanicity

Learning outcomes (You will be able to):

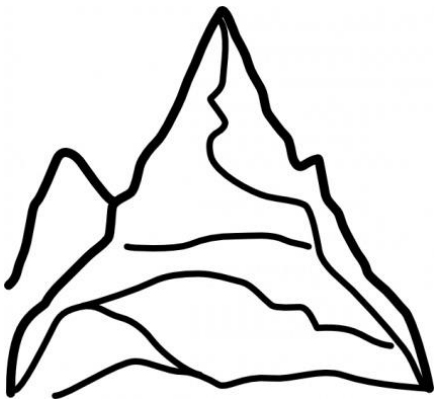
1. Discuss how plate movements influence the general distribution of landforms and associated phenomena
2. Describe the characteristics of landforms and phenomena associated with the plate movements
3. Explain the causes of landforms and phenomena associated with plate movements
4. Describe the structure of volcanoes
5. Explain the shape and size of volcanoes
6. Describe the benefits and risks of living in volcanic areas
7. Discuss the impact of earthquakes on people living in areas prone to natural hazard

Skill: Draw annotated cross section of a volcano

Skill: Draw labeled diagrams to show **formation** of Fold Mountain, rift valley, block mountain and volcano

***Landforms* found at plate boundaries**

The movement of plates at different plate boundaries can result in various landforms such as Fold Mountains, rift valleys and block mountains and volcanoes



Fold Mountains

Examples: The Himalayas, Rocky mountains and the Andes

- Fold mountains are formed along convergent plate boundaries
- The compressional force causes the layers of rocks to buckle and fold.
- This process is known as folding.
- The upfold is called the anticline and
- The downfold is the syncline.
- When there is increasing compressional force on one limb of a fold, the rocks may buckle until a fracture forms.
- The limb may then move forward to ride over the other limb
- Over millions of years, layers of rocks when compressed and folded form fold mountains
- Folding is more common in sedimentary rocks as they are more flexible

Rift valleys and block mountains

- Formed at divergent plate boundaries
- When plates pull apart, it gives rise to faults- a fracture in the rocks along which the rocks are displaced.
- The tensional forces from the movement result in parts of the crust being fractured. This process is called faulting.

A **rift valley** is a valley with steep sides formed along **fault lines**.
E.g. East African Rift Valley (divergent movement of Somalian boundary and Nubian boundary of the same African Plate.

A **block mountain** is a block of land with steep sides**.** It is formed when sections of the crust extend along fault lines and rock masses surrounding a central block sink due to tensional forces.

Note the difference between faulting and folding!

Folding	Faulting
1. Caused due to horizontal movements. 2. Forces move towards a common centre. 3. Due to compression, different types of folds are formed.	1. Caused generally due to vertical movements. 2. Forces move away from the common centre. 3. Due to tension, faults occur along which displacement of rocks take place

Volcanoes

- A volcano is a landform formed by magma ejected from the mantle onto the earth's surface
- Magma is molten rock found below the earth's surface and builds up within the crust to form a **magma chamber**
- Magma that is ejected onto the surface is known as **lava**.
- Upward movement of magma both into the earth's crust and onto the earth's surface is known as **vulcanicity**
- Parts of a Volcano
    - **Magma chamber-** a reservoir of molten rock beneath the earth's rust
    - **Vents**- openings in the earth's surfaces with a pipe leading up around the vent to form a volcano
    - **Crater**- bowl-shaped geological formation at the top of a volcano
    - **Calera**- a large crater caused by the violent explosion of a volcano that collapses into a depression

Cross section of volcano

How volcanoes are formed

Magma from the magma chamber rises to the surface through the vent. Magma is ejected onto the earth's surface as lava

Lava builds up around the vent, solidifying to form a small volcanic cone. The bowl-shaped opening is called the crater

When a volcano erupts, lava, ash and rock fragments are released. The force of the volcanic eruption depends on the amount of pressure and gas in the magma

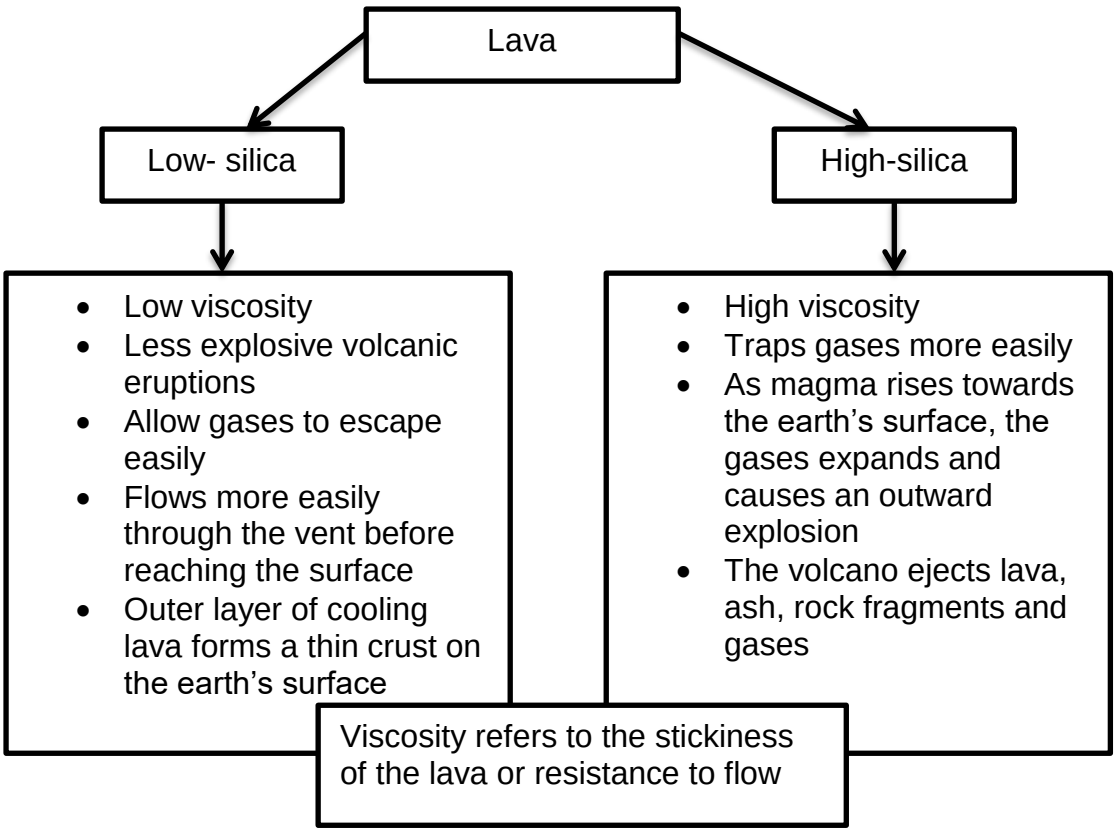
The summit of a volcano may be blown off during an explosive eruption. The sides of the crater collapse inwards due to the loss of structural support. As a result, a large depression known as caldera is formed.

New eruption of lava covers the ash layer and builds up the volcano

During the formation of the volcano, the vent may become blocked. This forces the magma to find a new exit route to the surface. A secondary cone of newer volcanic material will then develop.

Shapes and sizes of volcanoes

- Volcanoes vary in shapes and sizes due to the characteristics of the lava

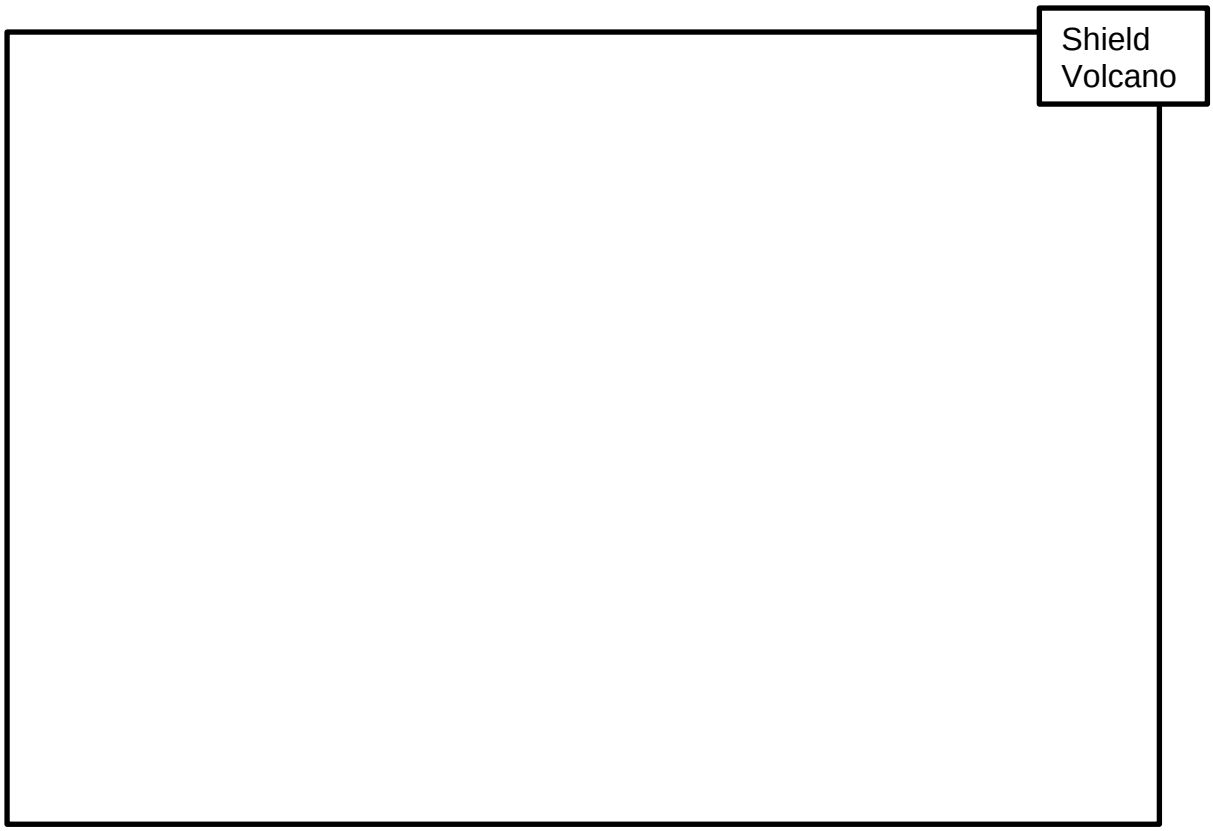


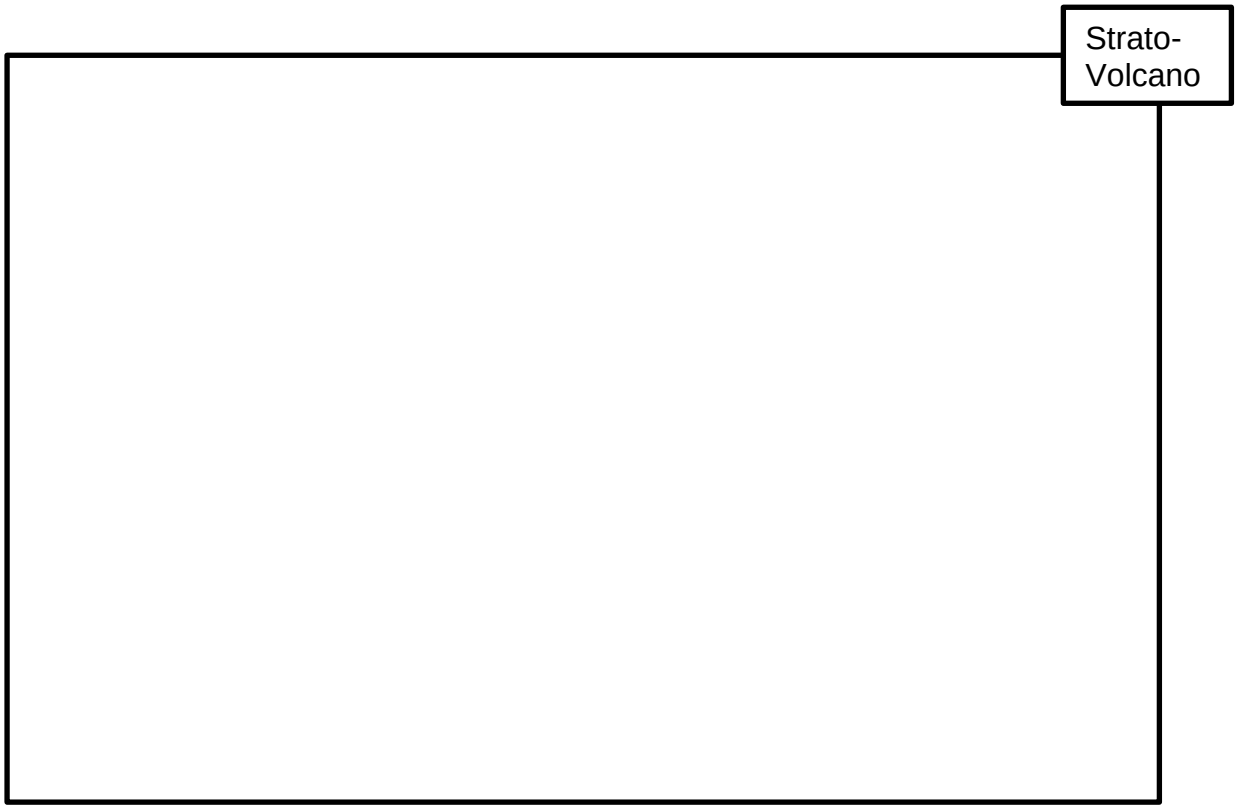
Shield volcanoes

- Gently sloping sides and a broad summit
- Low-silica lava flows easily and spreads out over a large area before solidifying
- Eruptions are usually not explosive, with successive eruptions, the base of the volcano increases in size as lava accumulates
- Common near divergent plate boundaries where magma can rise directly from the mantle
- E.g. Mount Washington, USA

Stratovolcanoes

- Steeper at the top, gentler at the base
- High silica lava solidifies faster near the top
- Develops from successive eruptions of lava and ash (may contain coarser rock fragments too)
- After the initial eruption, subsequent eruptions ejects lava which covers the soft ash and prevents it from being eroded away
- Over time, successive eruptions build a high volcano with slightly concave profile
- Secondary cones may develop as magma from the vent seeps into sides of the cones and erupts
- E.g. Mount Merapi, Indonesia

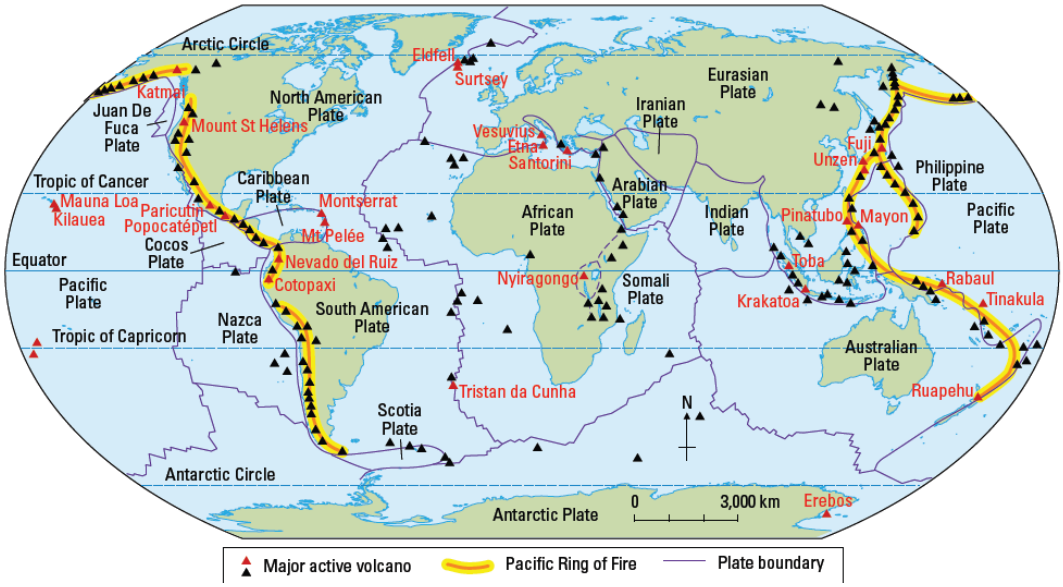

Shield
Volcano


Strato-
Volcano

Volcanic eruptions may result in pycroclastic flow and lahars:

Pyroclasts	Lahar
• Pyroclasts refer to hot rock fragments and super heated gases ejected during a volcanic eruption. • The movement of such rock fragments and gases down the slopes of an erupting volcano is known as pyroclastic flow	• Refer to a mixture of pycrolasts and melted ice fro the mountains • Wet volcanic debris flowing down the slopes of an erupting volcano

Pacific Ring of Fire



- Where most active volcano activity occurs
- Large number of earthquakes and volcanic eruptions occur along the edges pf the
- Found along the boundaries of several converging plates- the Pacific Plate, Nazca Plate, The Philippine Plate, Australian Plate and the Eurasian Plate
- There are volcanoes where tectonic plates are diverging too
- There is close correlation between the location of plate boundaries and the distribution of major active volcanoes

Phenomena at the plate boundaries

1. Earthquakes
2. Tsunamis
3. Volcanic eruptions

Earthquakes

An **earthquake** is a vibration in the earth's crust caused by the sudden **release of stored energy** in the rocks found along fault lines.

How are they formed?

Occurs when plate movements along plate boundaries cause the slow build up of stress on the rocks found on either side of the fault. When rocks can no longer withstand the increasing stress, they can slip suddenly and release releasing massive amount of energy, causing an earthquake.

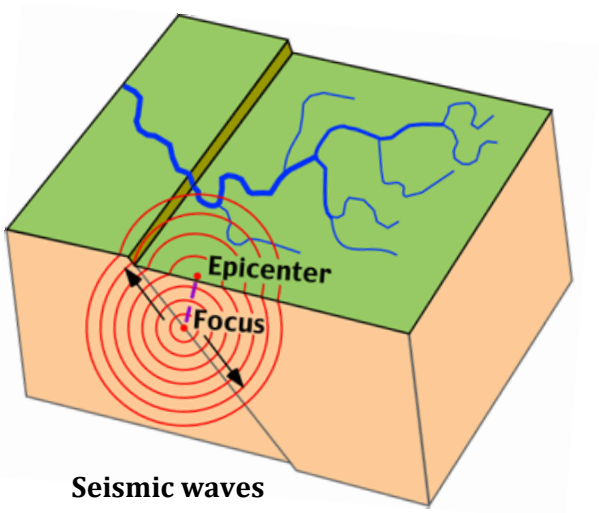
Earthquakes releases energy in the form of **seismic waves**. It radiates form a point of sudden energy release, called the **focus**. The depth of an earthquake's focus within the crust can have great impact on the land.

The point on the earth's surface directly above the focus is known as the **epicentre.**

Most of the energy released by an earthquake travels along the surface of the earth, causing the ground to vibrate violently.

Deep-focus earthquake	Shallow-focus earthquake
• Smaller impact on land • Vibrations of seismic waves takes longer to reach the surface and would have lost most of their energy by then	• Greater impact on the land • Vibrations of seismic waves reach the landsurface more quickly

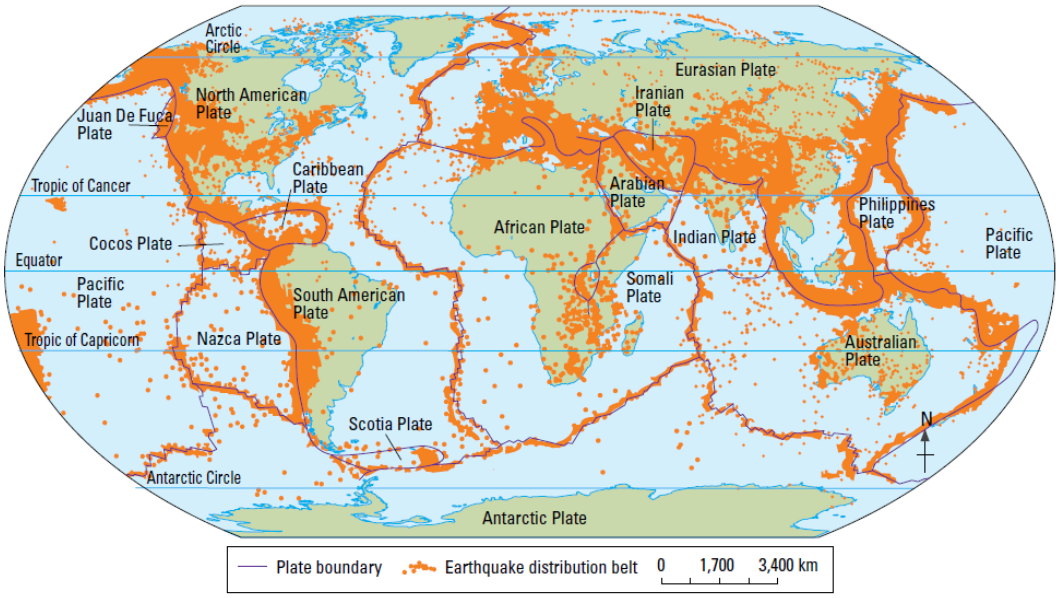
After an earthquake, the stress from the ground within the earth's crust may cause many smaller earthquakes called **aftershocks** to occur along the fault line. A series of aftershocks may occur for several months after the initial earthquake, with some aftershocks being nearly as powerful as the original earthquake.



Extent of damage caused by earthquakes is influenced by:

1. Magnitude of earthquakes	• The amount of energy released by earthquakes is described as the magnitude of an earthquake. • The Richter Scale measures the magnitude of an earthquake using a seismograph • The higher the Richter scale, the larger extent of damages
2. Population density	• Sparse VS densely populated areas • More casualties in densely population areas
3. Time of occurrence	• Time of the day determines what people are doing and will affect people's chance of survival • E.g. More casualties during sleeping hours
4. Level of preparedness	• Evacuation plans, trained workers and a range of action plans makes the damage more manageable
5. Distance from the epicentre	• Damage more severe when land is closer to epicentre
6. Type of soil	• Loose and unconsolidated sediments amplifies seismic waves, resulting in greater damage

Distribution of major earthquakes



- Earthquakes can occur at convergent, divergent and transform plate boundaries
- Occurs most frequently at convergent plate boundaries due to built up stress. E.g. In Tokoku, Japan earthquake in 2011 due to convergence of plates
- Around ¾ of the earthquakes are found along the Pacific Ring of fire

Hazards associated with living in earthquakes zones

Threat of tsunamis

- Tsunami refers to an usually large sea wave
- Tsunamis may be formed by:
  - The movement of the sea floor during a large earthquake at subduction zones
  - An underwater volcanic eruption
  - An underwater landslide
  - A landslide above sea level which causes materials to plunge into the water

- Can travel long distances and cause widespread destruction at coastal areas when it sweeps inland
- E.g. In 2004, 9.2 magnitude earthquake triggered in the Indian Ocean caused damange to coastal communities in 12 countries

Formation of Tsunami

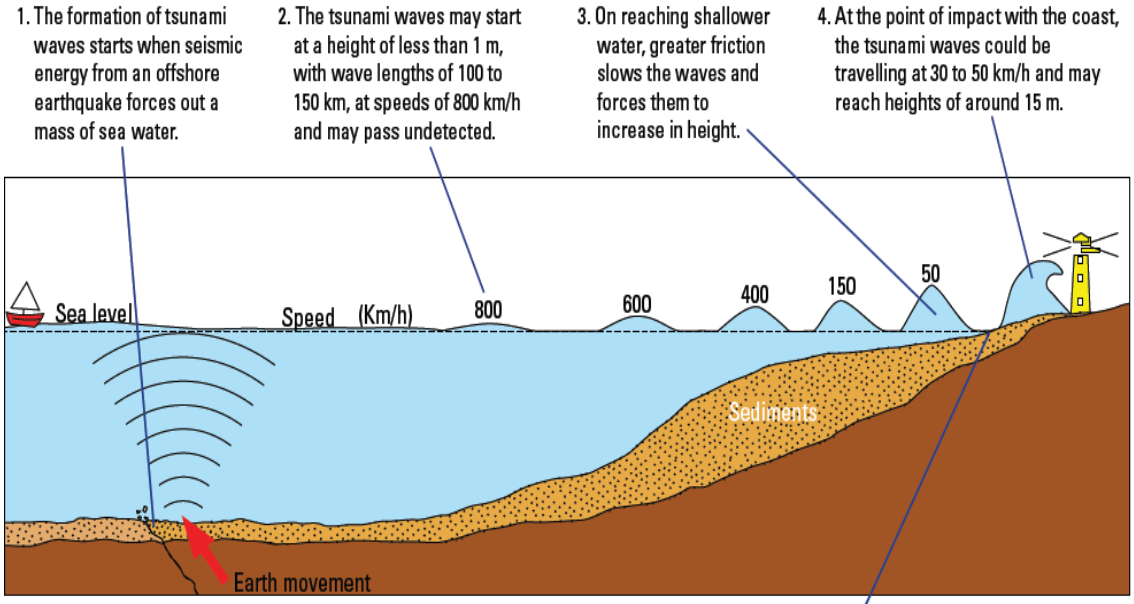


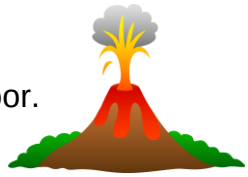
Figure 2.51 Formation of a tsunami.

5. Sometimes, the sea recedes from the coast before advancing onshore. If the sea recedes, it only does so minutes before the tsunami reaches the shore. The sea recedes because water first rushes to fill the void caused by the movement of the sea floor. Water is then forced out again soon afterwards, resulting in a tsunami.

Disruption of services • An earthquake can disrupt services such as the supply of electricity, gas and water. • The earthquake in Kobe, Japan, in 1995 disrupted electricity, gas and water supplies to about a million of Kobe city's 1.4 million residents.	**Fire** • Earthquakes may rupture gas pipes and this can provide fuel to start fires. • For example, the earthquake in Kobe, Japan, in 1995 caused extensive fires.
Landslides • Landslides are rapid downslope movements of soil, rock and vegetation. • Mudflows may also occur when there is heavy rainfall.	**Destruction of properties** • Earthquakes can cause destruction to many homes. • People may be without homes after the disaster.
Destruction of infrastructure • Earthquakes may cause cracks to form in infrastructure such as roads and bridges. • Transportation can be disrupted, as it is unsafe to use the damaged roads.	**Loss of lives** • Earthquakes and their associated hazards often threaten the lives of those living in earthquake zones.

Volcanic eruptions

- Occurs on land occur on the sea floor.



Volcanoes may be…

Active	Dormant	Extinct
Volcanoes that are currently erupting or are expected to erupt in the future	Currently inactive but may erupt in the near future	Volcanoes without current seismic activity

Risks of living near volcanic areas	Benefits of living near volcanic areas
Destruction by volcanic materials • Volcanic materials can lead to widespread damage of property • Low silica lava moves rapidly and flows over long distance, causing damage to larger areas • A pycoclastic flow can destroy everything in its path with its hot rock fragments ranging from ash to to boulders	**Fertile volcanic soil** • Lava and ash from the volcanic eruptions break down to form fertile volcanic soils • Favourable to agriculture • E.g. Volcanic soils of Java and Bali in Indonesia
Landslides • Landslides can occur due to the structural collapse of a volcanic cone • Obstruct the flow of rivers which causes floods, block roads, and bury villages and farmlands	**Precious stones and minerals, building materials** • Volcanic rocks can be rich in precious stones and minerals • These resources can only be from a volcanic area after millions of years. • E.g. diamond, sulphur
Pollution • Ash particles may block sunlight, suffocate crops, and cause severe respiratory problems for people and animals • Release of gases such as carbon dixoxide, sulphur dioxide, hydrogen and carbon monoxide may be harmful to people	**Tourism** • Volcanic areas offer a variety of activities for tourists to engage in- sightseeing, hiking, camping etc. • E.g. The ruins of Pompeii, Ital.

Effects on weather • Sulphur dioxide released from volcanic eruptions has impacts on the environment • It may react with water vapour and other chemicals in the atmosphere to form sulphur-based particles • These particles reflect the sun's energy back into space and temporarily cool the earth for periods of time.	**Geothermal energy** • Geothermal energy is derived from the heat in the earth's crust • The hot water or steam can be harnessed to produce electricity • E.g. Iceland

Summary

Plate boundary type	Associated landforms/phenomena	Example
Divergent: Oceanic- oceanic		
Divergent: Continental-continental		
Convergent: Oceanic- oceanic		
Convergent: Oceanic- continental		
Convergent: Continental-continental		
Transform		