SL IB Geography

Your notes

7.1 Geophysical systems

Contents

7.1.1 Tectonic Plate Movement

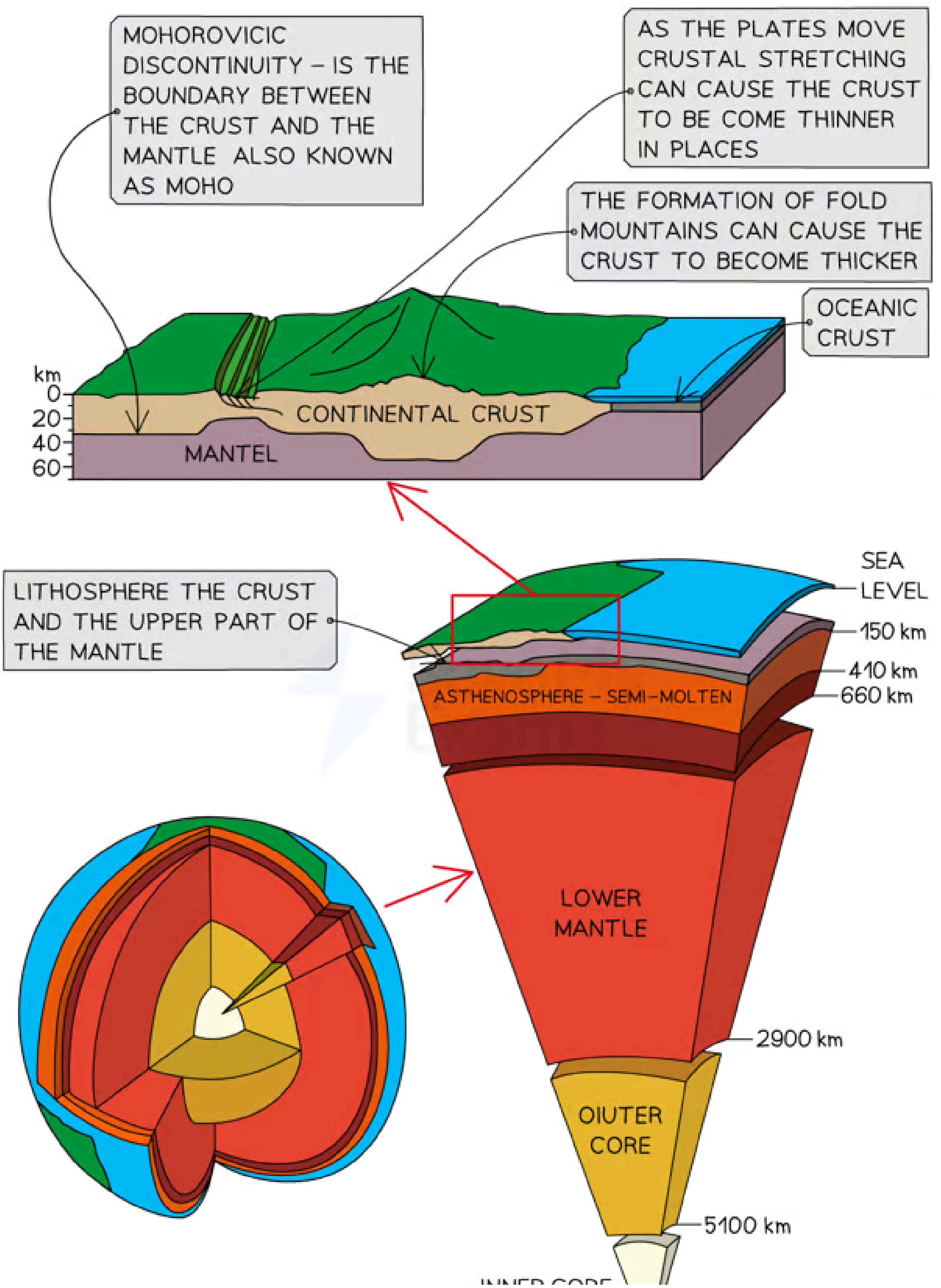
Your notes

Convection Currents

Earth's structure

- The Earth is composed of layers:
  - **Inner core:** About 1400km in diameter, a solid and dense layer composed of iron and nickel with temperatures of about 5500°C
  - **Outer core:** About 2100km thick, a semi-molten metal layer with temperatures between about 5000–5500°C
  - **Mantle:** About 2900km thick, a semi-molten layer that is less dense than the outer core
  - The **upper** mantle has two layers:
    - The rigid layer above the asthenosphere, which, together with the crust, makes up the lithosphere
    - The asthenosphere is a semi-molten, plastic-type layer, which moves under high pressure
  - **Crust:** The thickness varies, and is made up of two types of crust

Your notes


MOHOROVICIC DISCONTINUITY – IS THE BOUNDARY BETWEEN THE CRUST AND THE MANTLE ALSO KNOWN AS MOHO
AS THE PLATES MOVE CRUSTAL STRETCHING CAN CAUSE THE CRUST TO BE COME THINNER IN PLACES
THE FORMATION OF FOLD MOUNTAINS CAN CAUSE THE CRUST TO BECOME THICKER
OCEANIC CRUST
km
0
20
40
60
CONTINENTAL CRUST
MANTEL
LITHOSPHERE THE CRUST AND THE UPPER PART OF THE MANTLE
SEA LEVEL
150 km
410 km
660 km
ASTHENOSPHERE – SEMI-MOLTEN
LOWER MANTLE
2900 km
OIUTER CORE
5100 km

Your notes

Earth's structure

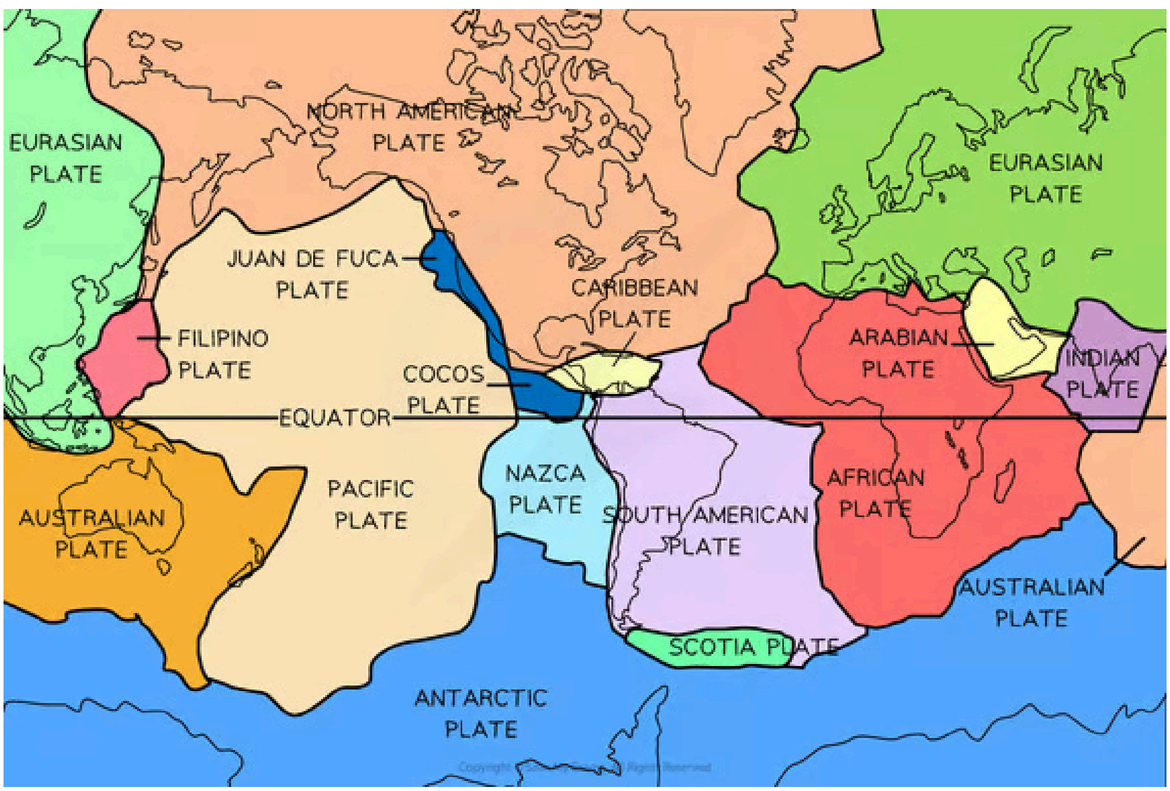
- The **Mohorovičić discontinuity** – also known as **Moho** – is the boundary between the crust and the mantle

Crust

- There are two types of crust:
  - **The oceanic crust**, which is thinner (5–10km) but heavier and denser
  - **The continental crust**, which is thicker (25–90km) but is older and lighter
- Oceanic crust is continually being created and destroyed as a result of plate movement:
  - The oceanic crust is denser and so subducts under the continental crust
- The continental crust is not destroyed and so is much older than the oceanic crust

Plate tectonics

- The crust is broken into several **tectonic plates**



Distribution of the major tectonic plates

- The tectonic plates move on top of the semi-molten mantle below
- A **plate boundary or margin** is where two plates meet

Convection currents

- In the past, the theory of convection currents was used on its own to explain tectonic plate movement
  - The heat from radioactive decay in the core moves upwards into the mantle, creating convection currents
- More recently there are the ridge push and slab pull theories:
  - **Ridge push** theorises that, as new crust is formed, it is pushed up into the spreading mid-ocean ridge, which forces them further apart
  - **Slab pull theory** suggests that movement is the result of the weight of the denser oceanic plates subducting and dragging the remainder of the plate along

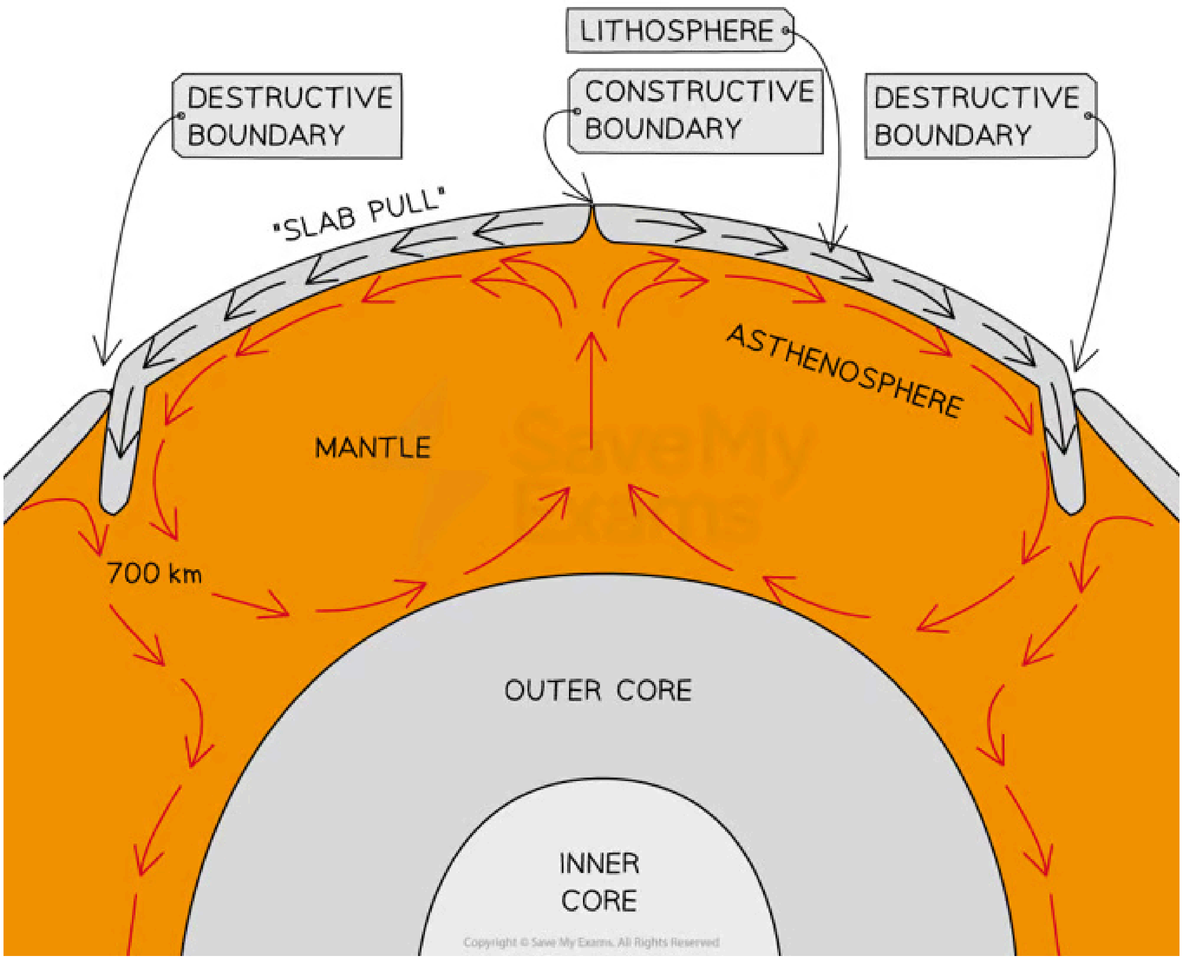


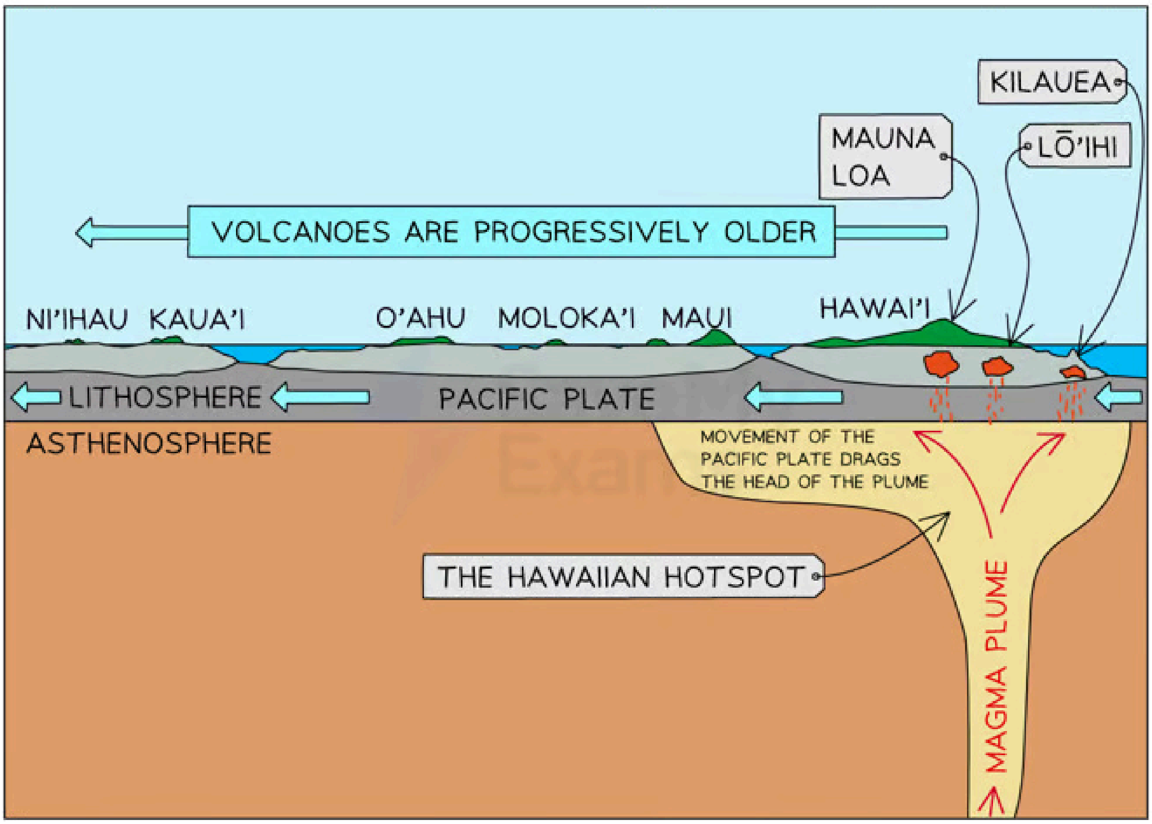
Diagram of convection currents

Your notes

Magma Plumes

Your notes

- **Intra-plate volcanism** is when volcanoes occur away from plate boundaries
- These are also known as **hot spots**
- At a hot spot the tectonic plate passes over a plume of magma:
  - The magma rises to the surface through cracks in the crust
  - As the tectonic plate moves slowly over the magma plume, a line of islands may form e.g. Hawaii



Intra-plate volcano formation

Subduction & Rifting

Your notes

Subduction

- Convection currents in the mantle drag the overlying lithosphere towards each other
- A subduction zone is formed when two plates meet and the heavier, denser plate subducts under the lighter, less dense plate:
  - As the oceanic crust cools, it becomes denser and heavier, and gravity forces the lithosphere down into the subduction zone
  - As it sinks, it drags or pulls the plate with it
  - This is known as slab pull

Rifting

- Rift zones are areas where the plates are moving apart from each other
- Most rift zones are beneath the oceans but a few are found on land, such as the Central African Rift
- As the plates move apart, magma rises to fill the space

Examiner Tip

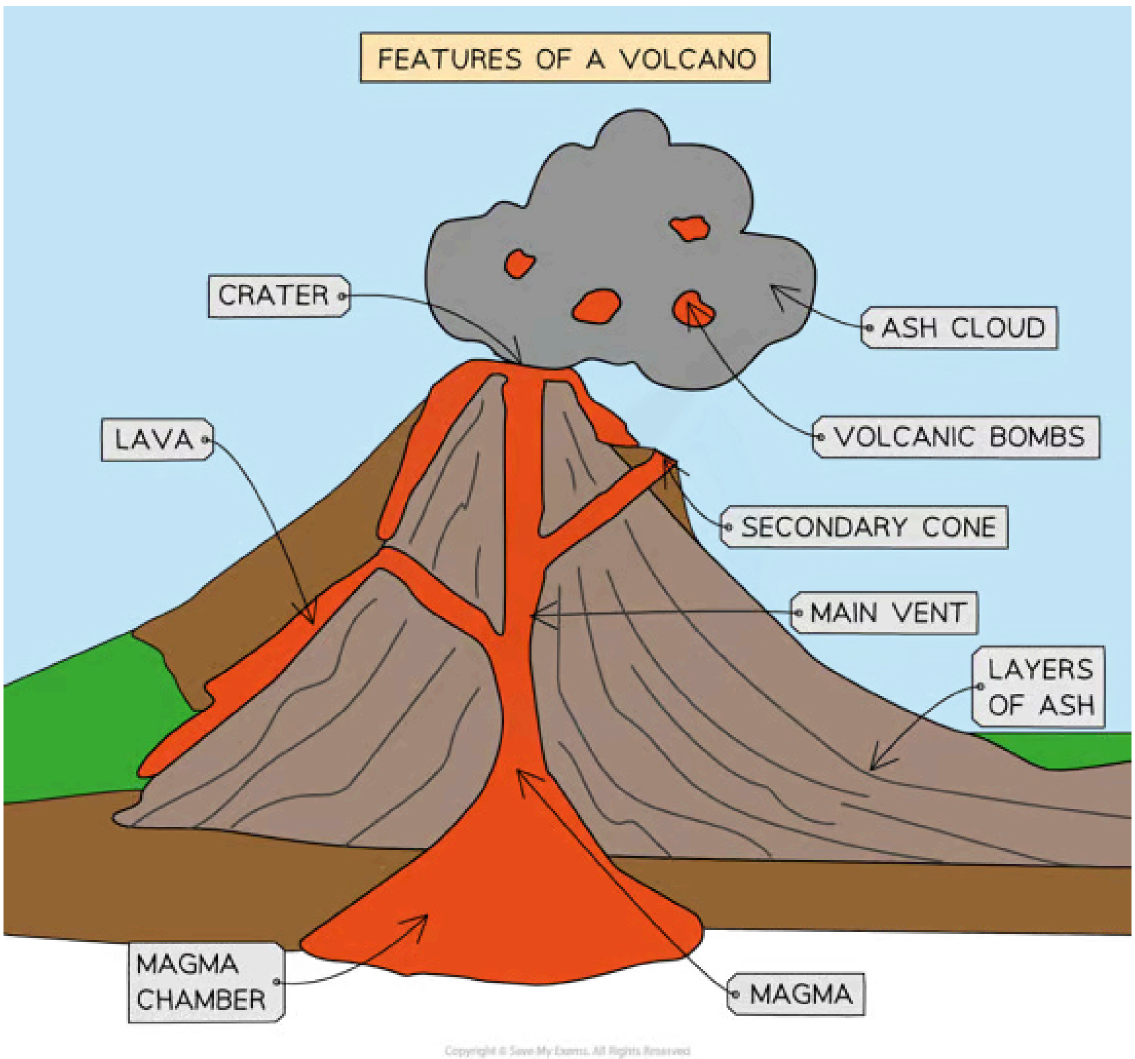
Make sure you can explain the contribution of each of the main processes that drive the movement of tectonic plates. Remember, it is a combination of all of these factors that cause the plates to move, leading to tectonic hazards.

7.1.2 Volcanoes

Your notes

Characteristics of a Volcano

- A volcano is formed when magma erupts onto the Earth's surface as lava through a vent in the Earth's crust
- The magnitude of a volcanic eruption is measured on the **Volcanic Explosivity Index (VEI)**:
  - The scale is open-ended but the highest in recorded human history was an 8 (Tambora 1815)
- All volcanoes have features in common, as shown in the diagram below:



Volcano characteristics

- Volcanic eruptions may include a range of features such as the ones listed in the table below

Features of an eruption

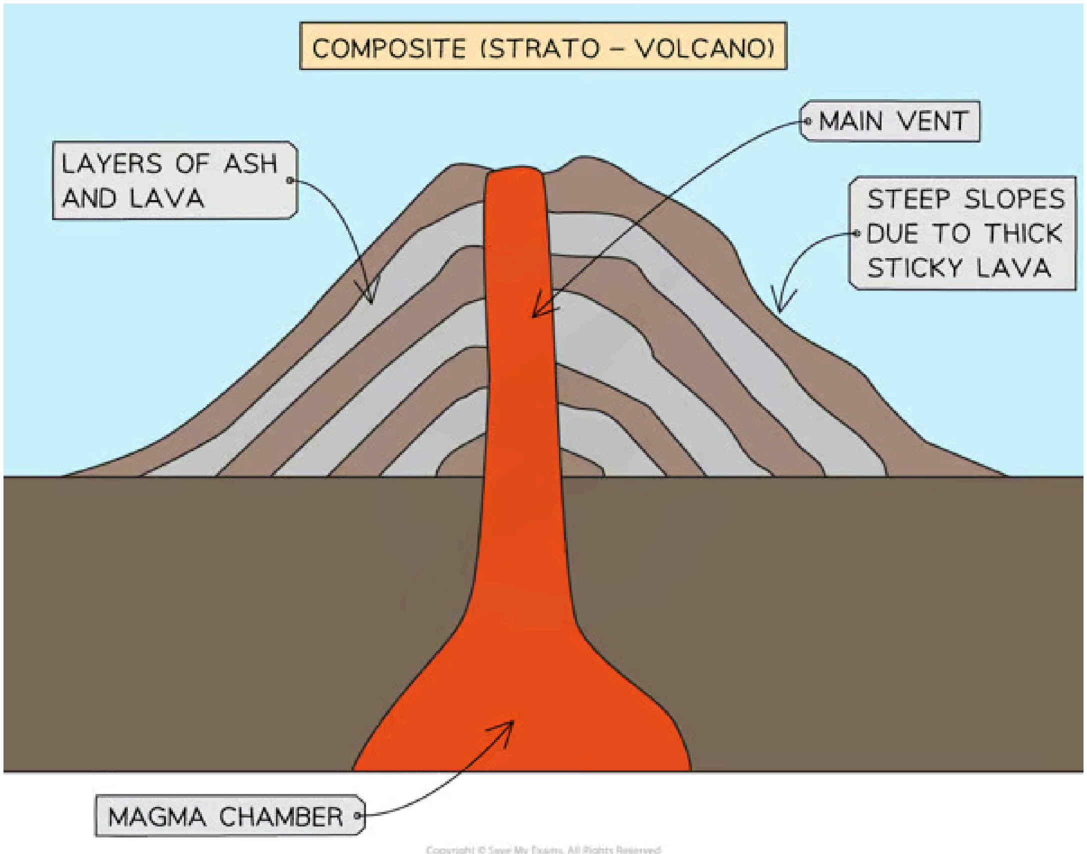
Feature	Characteristics
Lava	When magma erupts to the surface it is known as lava. The lava can be thin and runny or thick and slow moving. This depends on the composition of the magma
Ash	Ash is pulverised solid lava that measures less than 2mm in diameter. It is ejected into the atmosphere and can travel thousands of kilometres
Earthquakes	Magma rising to the surface through the vents in the volcano increases pressure on the Earth's crust, leading to earth tremors
Volcanic bombs	These are fragments of molten rock that are ejected from the volcano. They are between 60mm and 5m in diameter

- Due to the different types of eruption and lava, the formation of a volcano varies

Composite volcanoes

- **Composite** (strato-volcanoes):
  - Steep-sided
  - Sticky **(viscous)** lava
  - More explosive eruptions
  - Formed from alternating layers of ash and lava
  - Tend to form on convergent (destructive) plate boundaries

Your notes



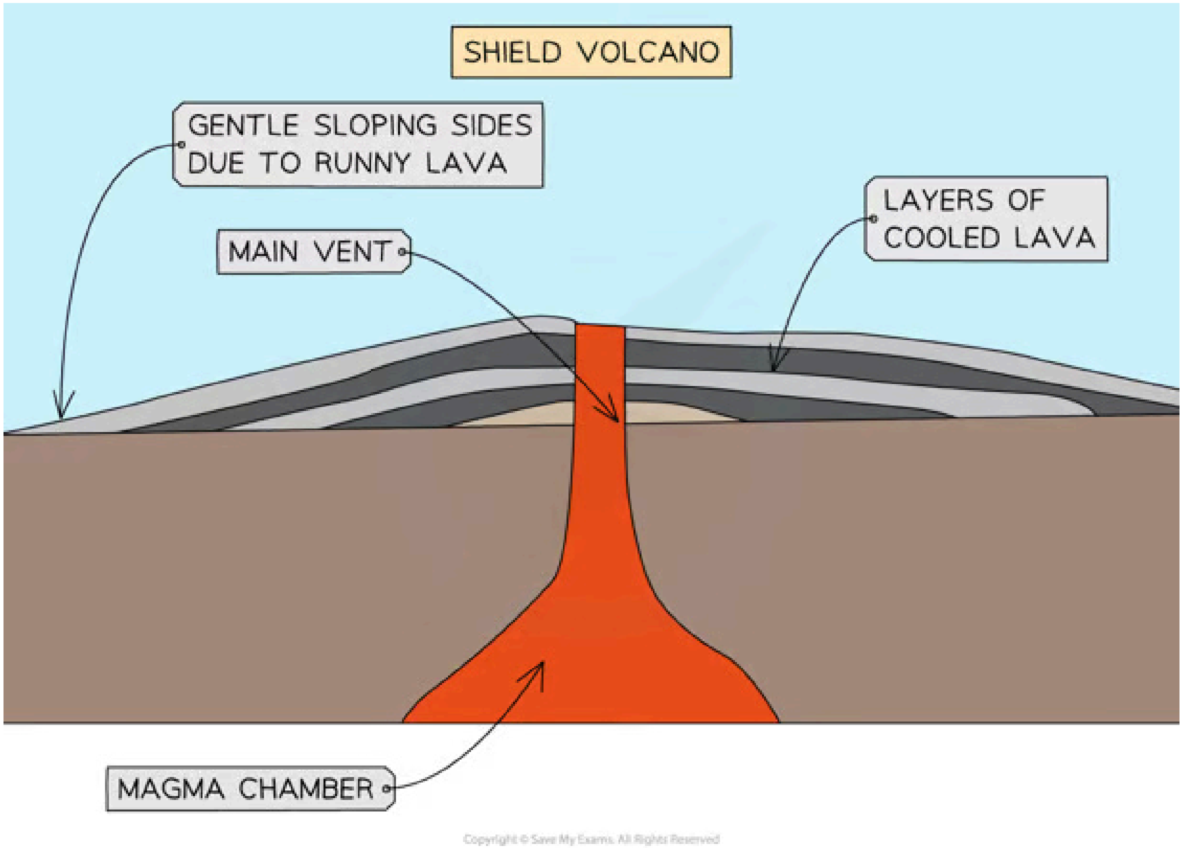
Composite volcano

Your notes

Shield volcanoes

- **Shield** volcanoes:
  - Gently sloping sides
  - Runny/thin lava
  - Less explosive – gentle eruptions
  - Tend to form on divergent (constructive) plate boundaries or hot spots
  - Frequent eruptions

Your notes



Shield volcano

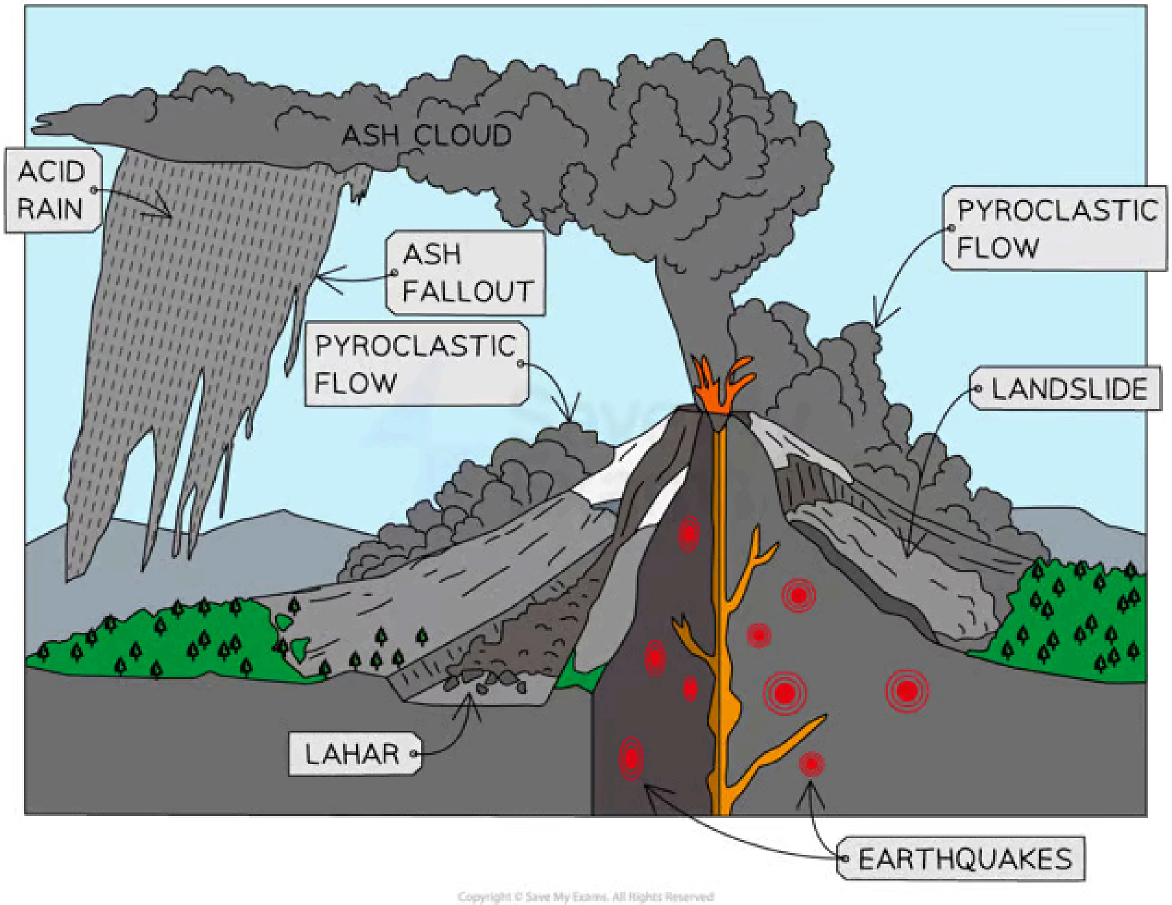
Cinder volcanoes

- Cinder volcanoes are:
  - Circular and cone shaped
  - Usually less than 1000 feet high
  - Composed of hardened ash, tephra and lava
    - The lava is forcefully ejected from the volcano and cools whilst in the air, falling as cinder fragments

Your notes

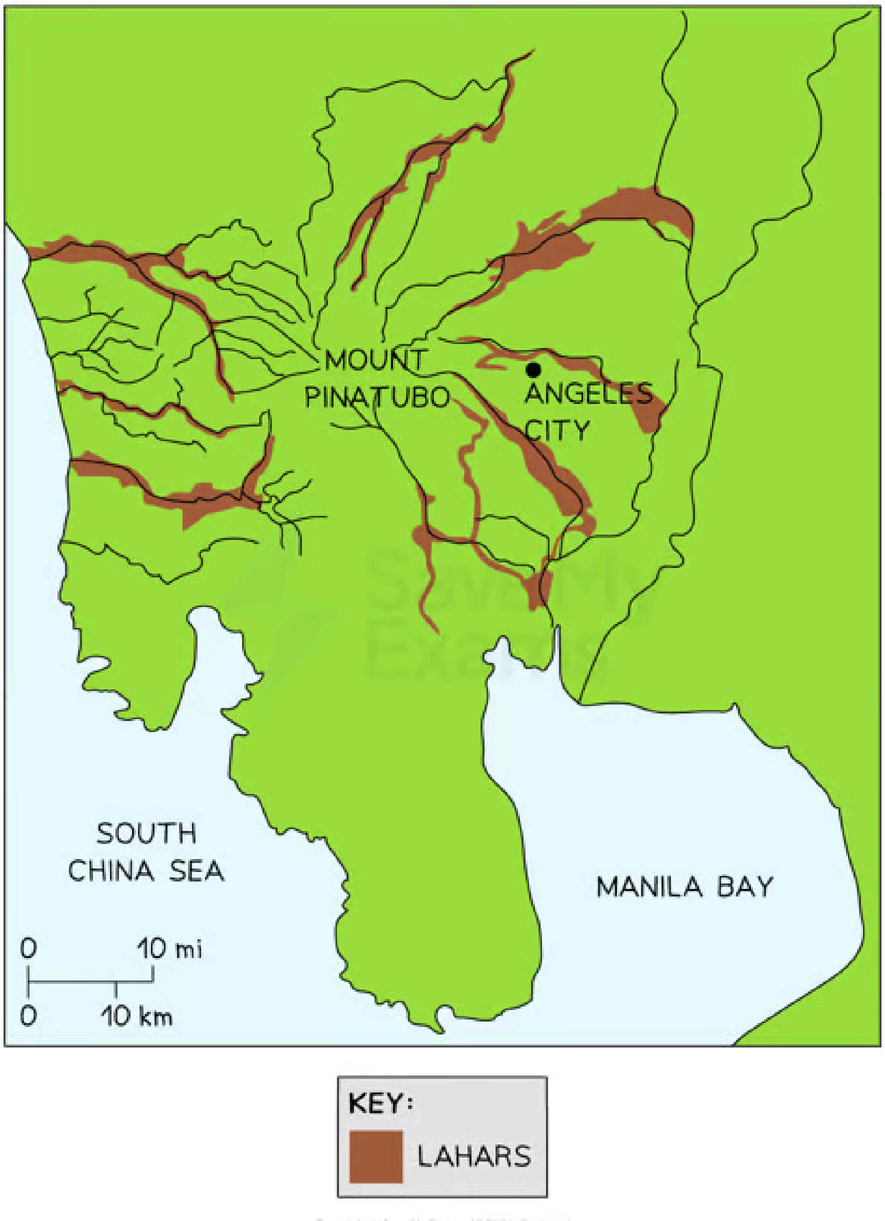
Secondary Hazards of Volcanoes

- There are a range of secondary hazards associated with volcanic eruptions



Volcanic hazards

- **Lahars** – mudflows that occur when tephra mixes with water, either from rainfall or from melted snow and ice
  - They are fast-flowing and destroy everything in their path
  - E.g. the lahars that occurred when Mount Pinatubo erupted in the Philippines in 1991 caused extensive damage and disruption
  - Lahars are usually associated with composite volcanoes



Map showing the extent of lahars in an eruption of Mount Pinatubo

- **Pyroclastic flow** – a super-heated mixture of gas and tephra that flows at speeds of up to 700km per hour:
  - This is one of the deadliest volcanic hazards as the pyroclastic flow can travel long distances and destroy everything in its path
  - E.g. when Fuego volcano erupted in Guatemala in 2018, pyroclastic flows destroyed several nearby towns

    - Pyroclastic flows are usually associated with composite volcanoes
- **Landslides** – the mass movement of materials down a slope occurring when the rock is no longer able to resist the force of gravity:
    - This can occur during volcanic eruptions due to the movement of the crust
    - Landslides can also cause a tsunami if the debris falls into the sea

Your notes

Examiner Tip

You may be asked in the exam to examine the relationship between secondary hazards and the type of volcano. For example, pyroclastic flows are usually the result of highly explosive eruptions from composite volcanoes.

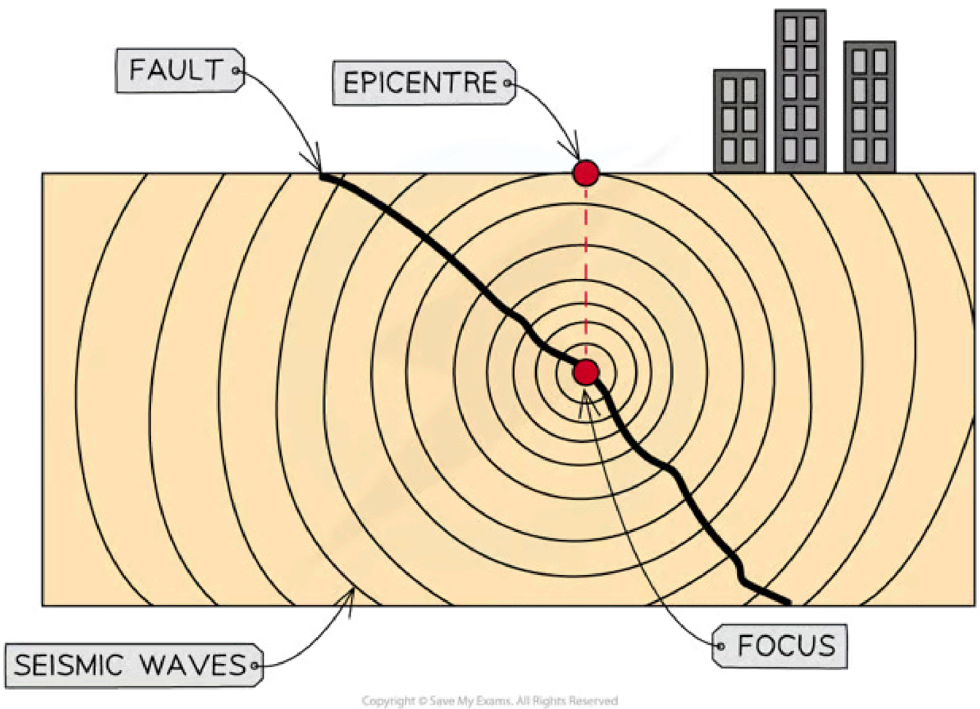
7.1.3 Earthquakes

Your notes

Earthquakes

Earthquake characteristics

- An earthquake is the sudden, violent shaking of the ground
- Earthquakes are the result of pressure building when **tectonic plates** move
- The violent shaking of the ground is the release of this pressure as energy travelling through the crust
- The **epicentre** is the point on the Earth's surface directly above the focus
- The **focus** is the point at which the earthquake starts below the Earth's surface: the energy released by the earthquake travels out from the focus



Earthquake features

- The **magnitude** (amount of energy released) by earthquakes is measured on the **Moment Magnitude Scale**, which replaced the **Richter scale**
- **Seismometers** are used to measure the magnitude
- The damage caused by earthquakes is measured on the **Mercalli Scale**

Seismic waves

- The movement felt during an earthquake is the result of seismic waves
- These are the released energy radiating through the Earth

Your notes

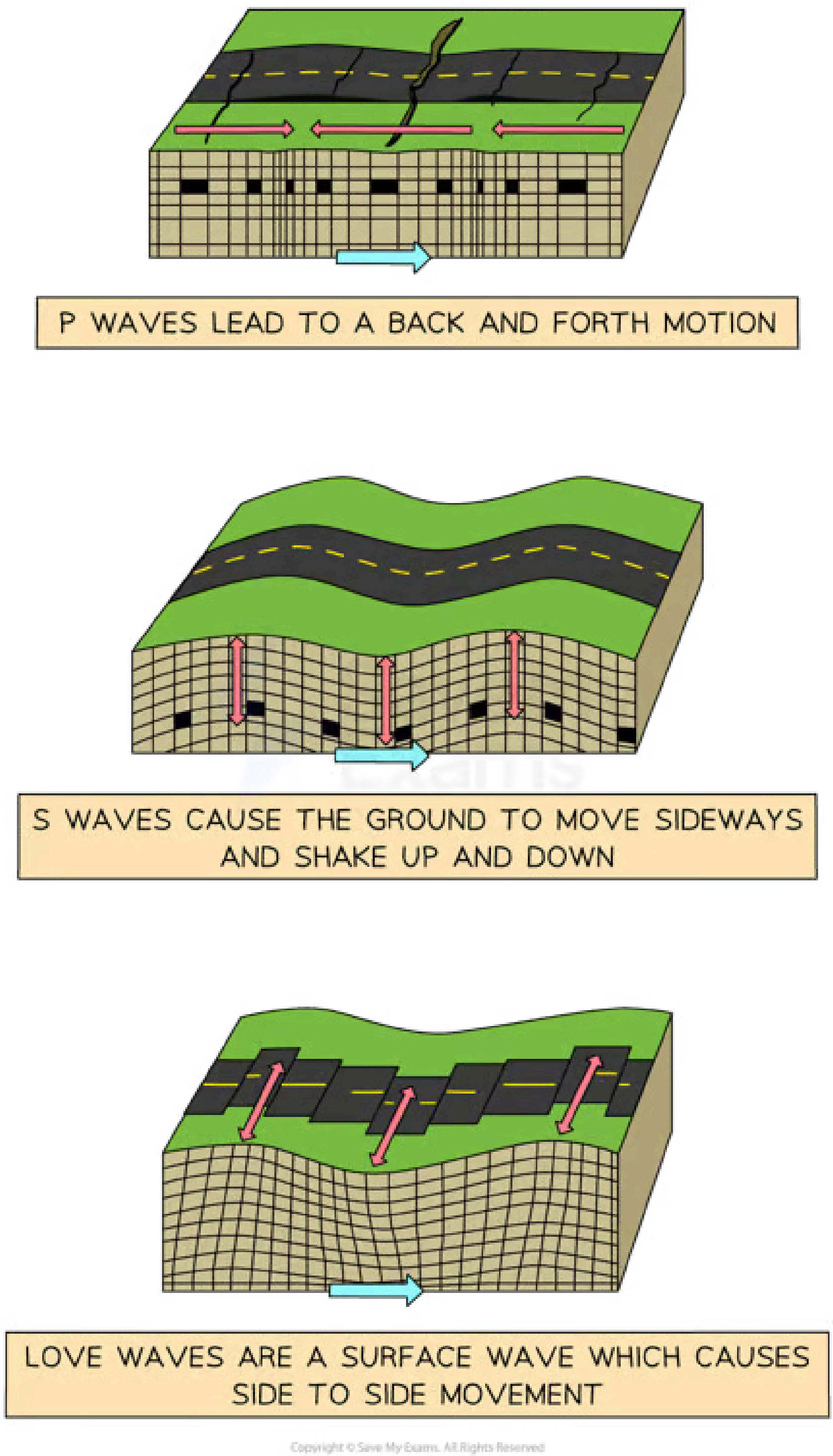
- There are three types of seismic waves:

Characteristics of Seismic Waves

Wave type	Characteristics
Primary - P Waves	Body waves Fastest Reach the surface first Travel through liquids and solids Cause backwards and forwards shaking Least damaging
Secondary - S Waves	Body waves Slower than P waves Only travel through solids Cause a sideways motion More damaging
Love - L Waves	Surface waves Slowest Cause a side-to-side motion Larger and energy is focussed on the surface Most damaging Also known as Q waves

- The differences in the seismic waves can be seen in the effect they have on the crust

Your notes



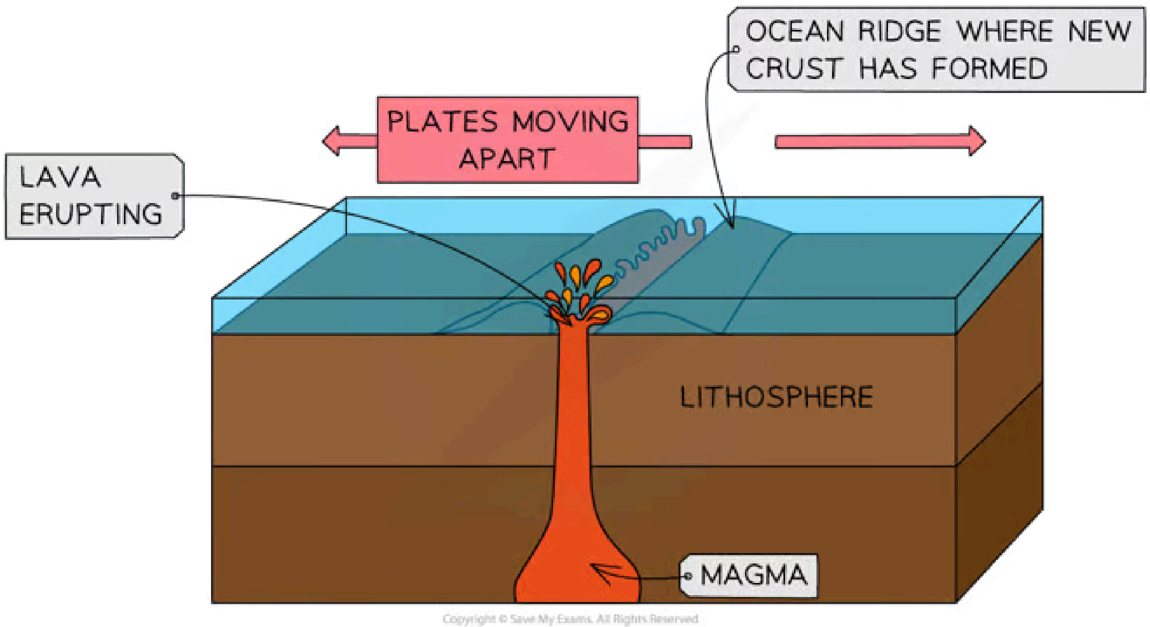
Seismic waves and their effect on the crust

Causes of an Earthquake

- Earthquakes can occur anywhere but mostly occur at or near plate boundaries
- Earthquakes happen at all plate boundaries: constructive, destructive, collision zones and conservative
- Plate movement leads to the build-up and then release of pressure

Constructive plate boundary

- At a constructive plate boundary, earthquakes are weaker as the plates are moving apart



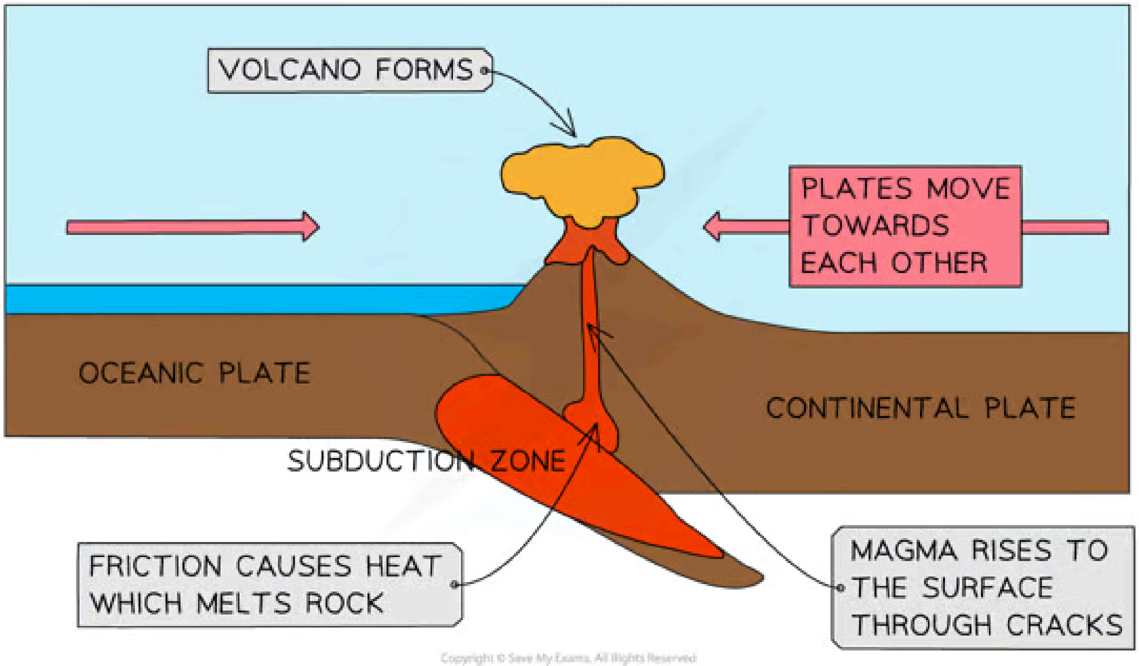
A constructive plate boundary

Destructive plate boundary

- At destructive, collision and conservative plate boundaries, earthquakes are stronger
- At destructive boundaries, the narrow area where earthquakes tend to occur in the subduction zone is known as the **Benioff Zone**

Your notes

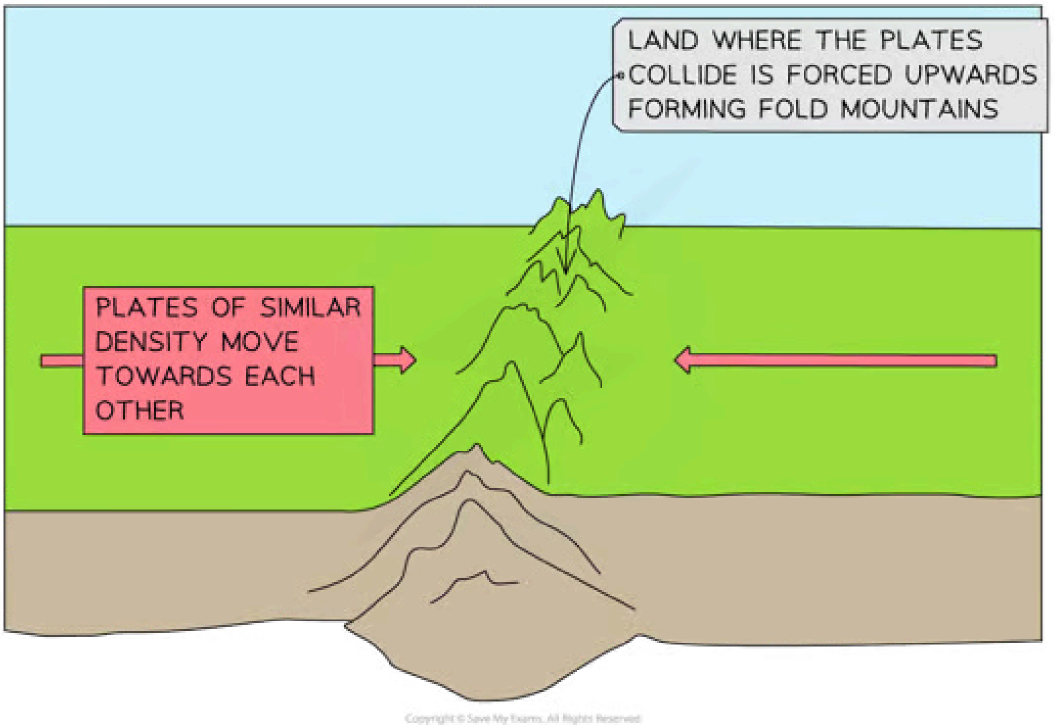
Your notes



Destructive plate boundary

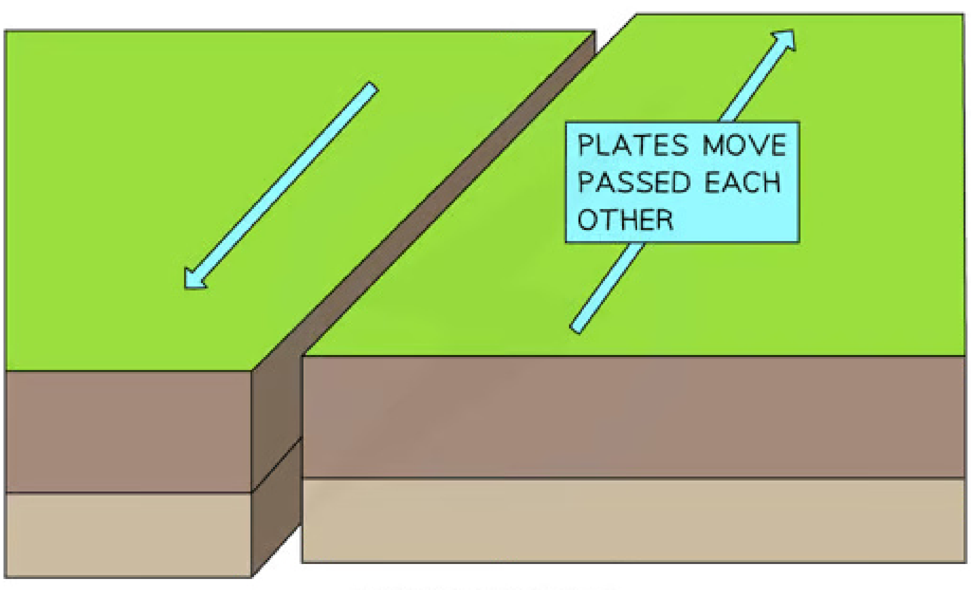
Collision plate boundary

Your notes



Collision boundary

Conservative plate boundary



Conservative plate boundary – note that conservative plate boundaries can also move in the same direction but at different speeds

Your notes

Human Triggers of Earthquakes

- Human activity may trigger earthquakes
- Evidence suggests that dam building and resource extraction may trigger earthquakes

Dam building

- The building of dams leads to the formation of a reservoir
- The added weight of the water in the reservoir adds stress to fault lines, causing them to fracture:
  - The weight of water in the **Three Gorges Dam** is 84 trillion pounds
- Additionally, water seeps into cracks along the fault line, changing the pressure levels
- Scientists believe that the **Sichuan earthquake** was in part caused by the construction of the **Zipingpu Dam**:
  - The reservoir at Zipingpu contains water weighing 315 million metric tons
  - The added weight weakened the fault and increased the stress
  - The effect of this was 25 times that of a year's worth of natural stress
  - The earthquake in 2008 killed over 80,000 people

Resource extraction

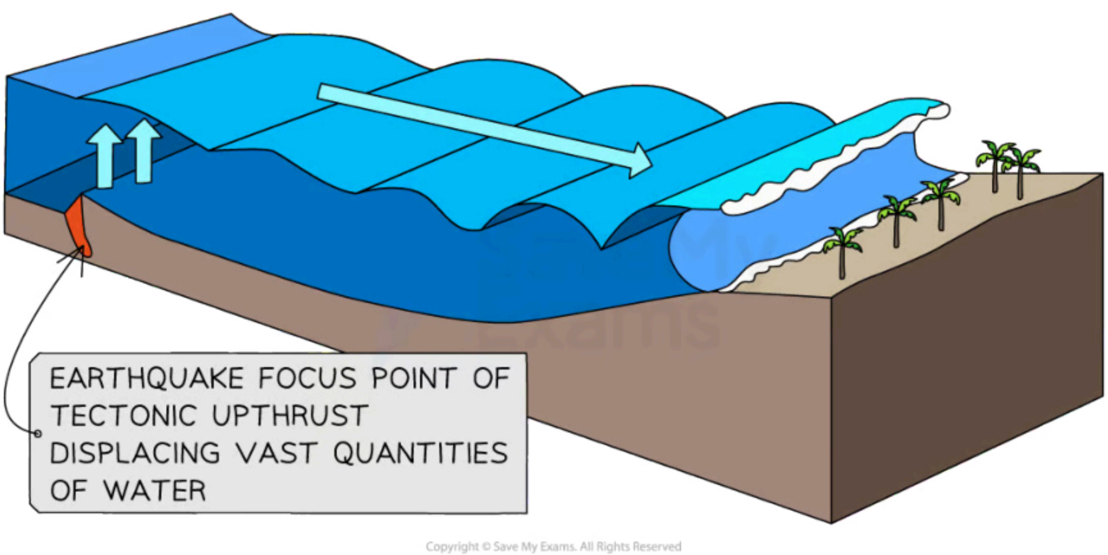
- The injection of water at high pressure is used to crack rock formation in hydraulic fracturing or fracking
- This allows gas to be extracted
- This was the cause of the 2.9–magnitude Lancashire earthquake in the UK in 2019

Secondary Hazards of Earthquakes

Your notes

Tsunami

- When an earthquake occurs beneath the sea bed this can lead to a tsunami:
  - As the sea bed jolts due to the release of pressure, water is displaced and forced upwards, creating a wave
  - As the wave approaches the land it slows and the wavelength becomes compressed:
    - This leads to an increase in wave height; they frequently reach 5–10 metres, but can reach as high as 30 metres
  - As the wave reaches the shore, a vacuum is created and the water recedes rapidly out to sea, leaving the sea bed exposed



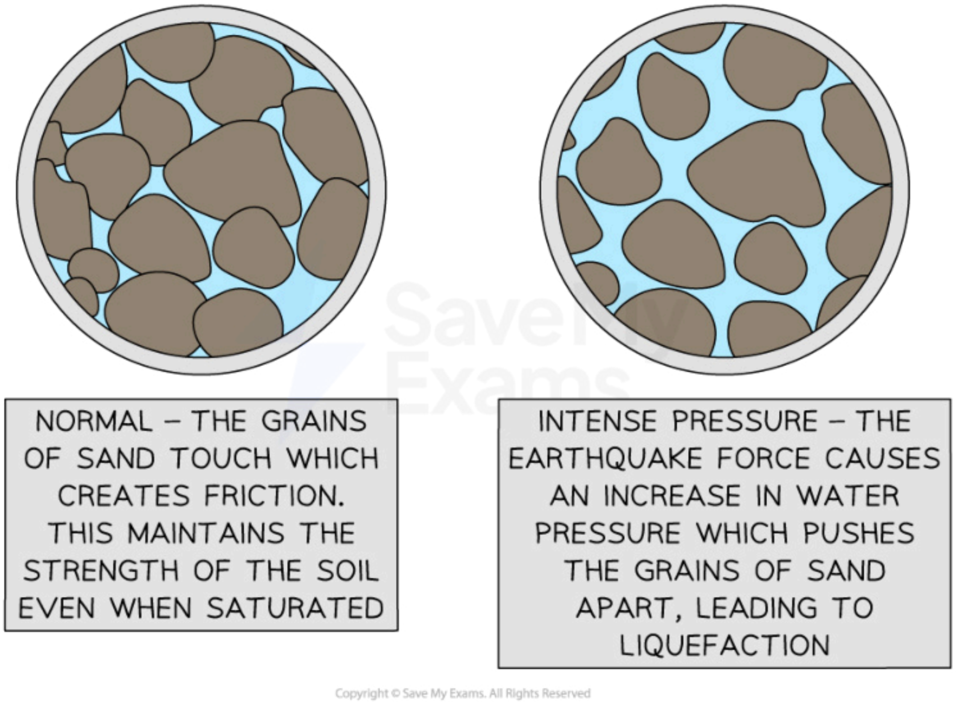
Tsunami formation as a result of an earthquake

- Other causes of tsunami include:
  - **Landslides**, which may be due to earthquake and volcanic eruptions displacing the water
  - Underwater volcanic eruptions
  - Rarely, they can be caused by a meteor strike
- Tsunami usually occur close to plate boundaries and are most common in the area surrounding the Pacific Ocean – the "**Ring of Fire**"

Liquefaction

- Liquefaction occurs when the shaking causes particles in the ground to move further apart, causing it to act like a liquid rather than a solid
- The process occurs when saturated, unconsolidated soil is affected by the s-waves in an earthquake
- This causes the water-filled pore spaces to collapse
- It increases the water pressure and the soil particles can move more freely

- This causes the soil to behave like a liquid and buildings to collapse



Liquefaction

Your notes

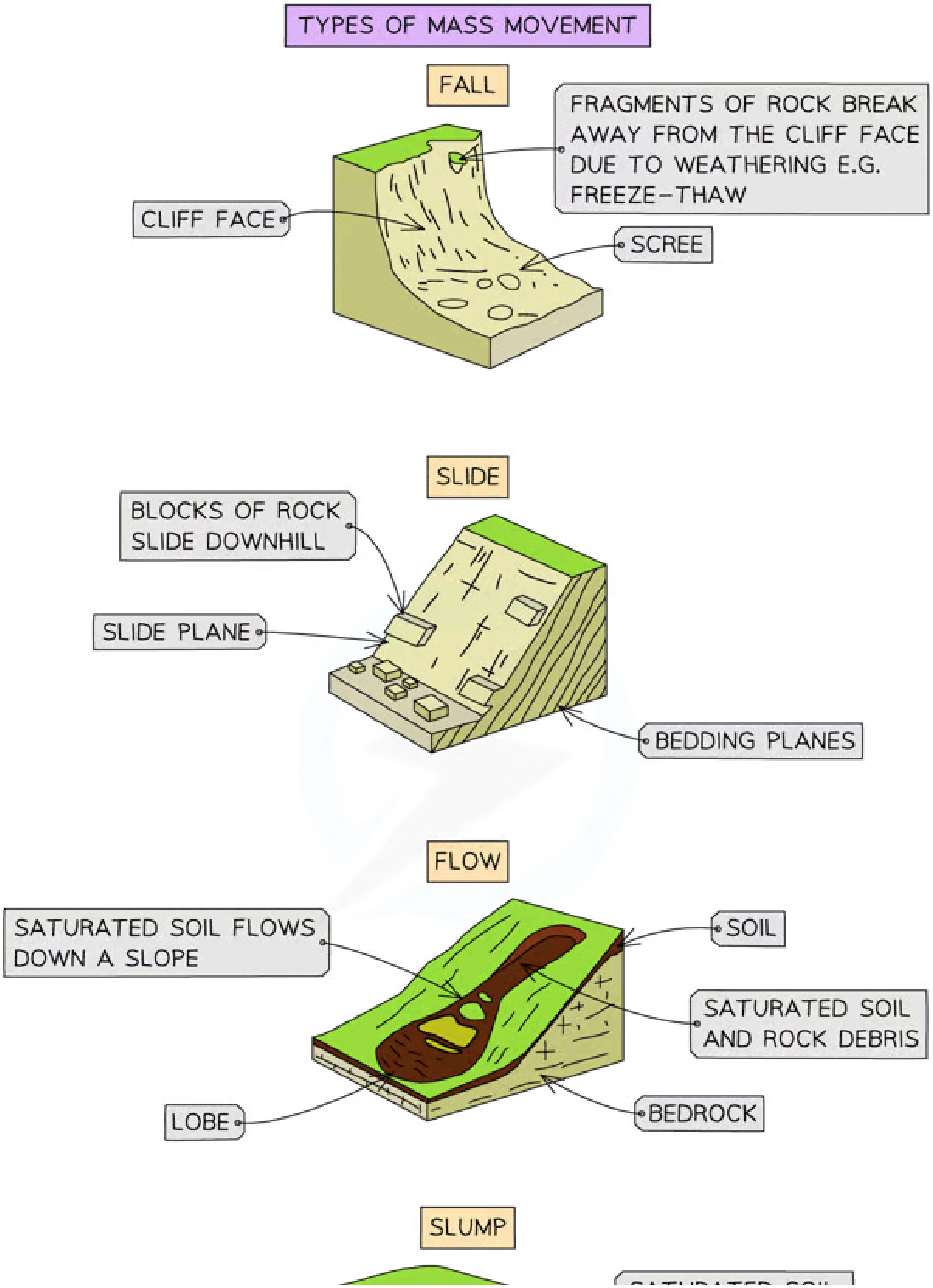
7.1.4 Mass Movement

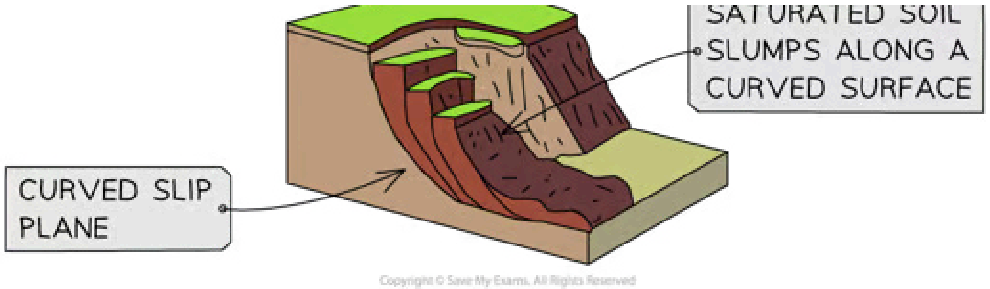
Your notes

Mass Movement

- Mass movement is the downhill movement of material under the influence of gravity
- Throughflow and runoff caused by heavy rain can also make slopes more unstable and increase the likelihood of mass movement
- Mass movement includes landslides, slumping and rockfalls
- **The type of movement is influenced by:**
  - Angle of slope (steeper is faster)
  - Nature of regolith
  - Amount and type of vegetation
  - Water
  - Type and structure of rock
  - Human activity
  - Climate
- **Soil Creep:**
  - Speed is below 1cm per year
  - Common in humid climates
  - When soil expands, individual particles are lifted up at right angles to the slope
  - Soil also expands when it freezes, gets wet or is heated up in the sun
  - When the soil shrinks again, the particles fall straight back down
  - Soil creep takes a long time because the soil moves only a millimetre to a few centimetres at a time
- **Flow:**
  - Occurs on slopes between 5° and 15°
  - Usually after the soil has become saturated with a flow of water across the surface
  - Vegetation can be flattened and carried away with the soil
  - Speeds range from 1km to 15km per year
- **Slide:**
  - A movement of material 'en masse', which remains together until hitting the bottom of a slope
- **Fall:**
  - Slopes are steep and movement is rapid
  - Caused by a number of factors:
    - Extreme weathering – freeze-thaw action can loosen rocks that become unstable and collapse
    - Rainfall – too much rain will soften the surface, leading to collapse of the slope
    - Earthquakes can dislodge unstable rocks
    - Hot weather can dry out soil, causing it to shrink and allow rocks to fall
- **Slump:**
  - Usually found on weaker rock types (i.e. clay), that become saturated and heavy
  - This is common at the coast and is also known as **rotational slip**
  - It involves a large area of land moving down the slope in one piece
  - Due to the nature of the slip, it leaves behind a curved surface

Your notes


TYPES OF MASS MOVEMENT
FALL
FRAGMENTS OF ROCK BREAK AWAY FROM THE CLIFF FACE DUE TO WEATHERING E.G. FREEZE–THAW
CLIFF FACE
SCREE
SLIDE
BLOCKS OF ROCK SLIDE DOWNHILL
SLIDE PLANE
BEDDING PLANES
FLOW
SATURATED SOIL FLOWS DOWN A SLOPE
SOIL
SATURATED SOIL AND ROCK DEBRIS
LOBE
BEDROCK
SLUMP



Types of mass movement

Your notes