Managing natural hazards

Grade 10A EVM

Supervolcano (Yellowstone National Park)

- Eruption measures magnitude 8
- Deposits greater than 1000 km^{-3}
- If it erupts today:
- 90,000 people killed instantly
- 3m layer of ash up to 1000 km
- Between 2005 & 2015
- Natural hazards killed over 700,000 people
- Economic loss of more than 1.3 trillion US$

Natural hazard: A naturally occurring event that will have a negative impact on people.

1. Geological hazards (Earthquakes and volcanoes)
2. Climatic hazards (Droughts, cyclones, floods)

Natural disaster: When a natural hazard causes damage and the people affected are unable to cope.

Natural hazard (for example flooding) +**factors effecting possible risk** (for example high population density) = **Natural disaster** (for example many people killed)

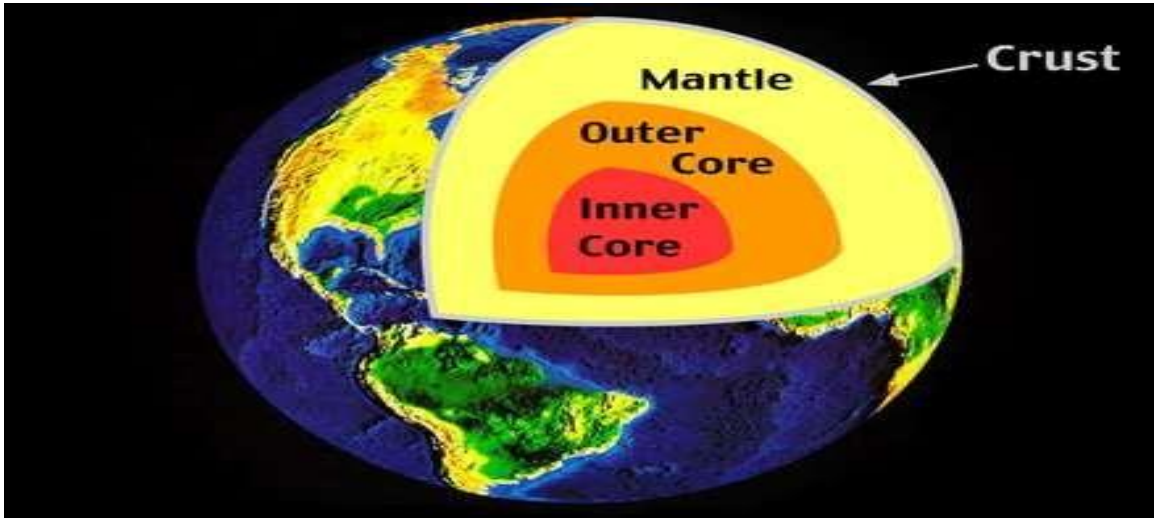
Impact of a natural disaster on a community depends upon:

a) Length of time people are exposed to the natural hazard
b) Vulnerability (more susceptible) of the people affected
c) People's ability to cope with the effects

What causes earthquakes and volcanic eruptions?

Plate tectonics is the answer.

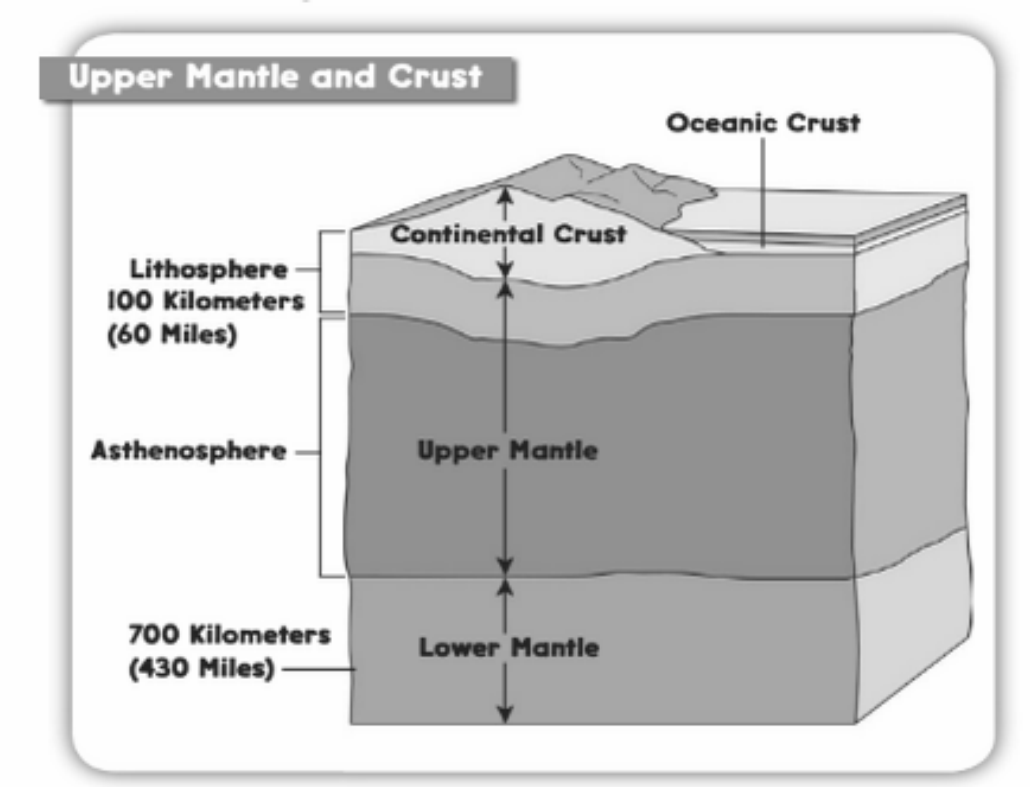
- Theory developed in 1960s that helps explain the formation of some of the important features on the Earth's surface and how the continents move.
- It helps explain the global distribution and causes of volcanoes, earthquakes and fold mountains.



- **Mantle**: Lower mantle is called the **asthenosphere** and has a temperature of 1000-1200°C. It behaves like a plastic and flows slowly due to convection currents created by heat from the core.
- The upper part of the mantle is more brittle and joins with the top layer (crust) of the earth and called the **lithosphere.**
- **Convection currents** - convection currents occur when a heated fluid expands, becoming less dense, and rises. The fluid then cools and contracts, becoming denser, and sinks.

TABLE 1 Interior Properties of Earth

Property	Crust	Mantle	Core
Fraction of Earth	<1% of mass	~70%	~30%
State	"Broken rock"	Plastic	(Semi-)liquid
Depth (kilometers)	0–30	30–3030	3030–6370
Density (grams/cubic centimeter)	2.7	3.5–5.5	10–12
Representative chemical composition	SiO_2	$(Fe,Mg)SiO_4$	Fe, Ni
Temperature (Kelvin)	300–500	500–3,000	3,000–5,300
Pressure (atmospheres)	1–1,000	10^3–10^6	10^6–10^7



Asthenosphere: The layer of the earth below the lithosphere, it is hotter and weaker than the lithosphere above and is capable of plastic flow.

Oceanic crust vs Continental crust

Continental Crust

- Located beneath land masses and under shallow seas close to continents
- Very thick — between 35 and 70 km
- Lighter rock(e.g. granite)

Oceanic Crust

- Located beneath deep ocean
- Very thin — between 5 and 8 km
- Dense and heavy rock(e.g. basalt)

Sial versus Sima

Continental crust (Sial): Sial is composed of silicon and aluminium. It is upper layer which forms a discontinuous cover over the Earth's crust, mainly made of granite rock and entirely absent in the ocean floor. It is thicker, lighter, older and cannot sink.

Oceanic crust (Sima): Sima is composed of silicon and magnesium. It is the second layer below sial, mainly made of basalt rock, which forms the ocean base. It is thinner, denser, younger and can sink.

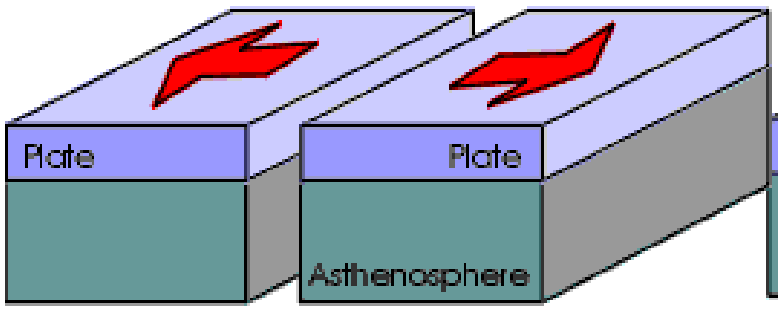
- **Tectonic plate:** a piece of lithosphere that moves slowly on the asthenosphere. It is made of crust and upper mantle. Seven major, eight minor and numerous micro plates have been identified.

- Where the convection currents rise to the surface, the plates move away from each other.

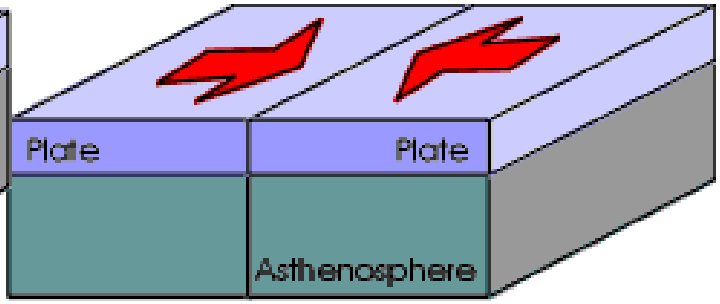
- Where the convection currents sink, plates move towards each other.

Plate Boundaries

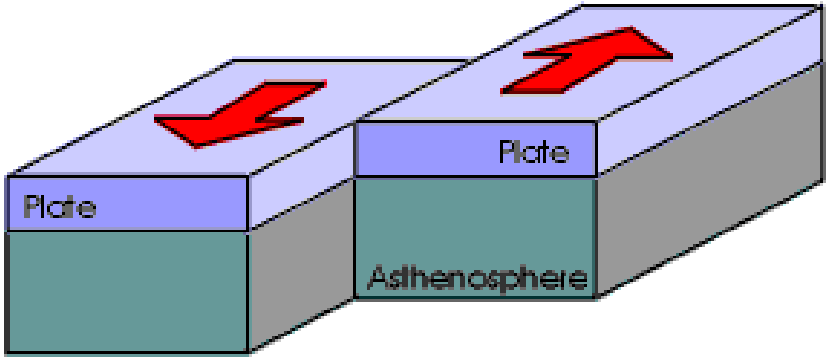
- At the locations where two tectonic plates interact, a boundary between these plates is called PLATE BOUNDARIES
- There are three types of boundaries.
- These boundaries are Constructive (divergent) boundaries, Destructive (convergent) boundaries, and Transform (conservative) boundaries.



Divergent



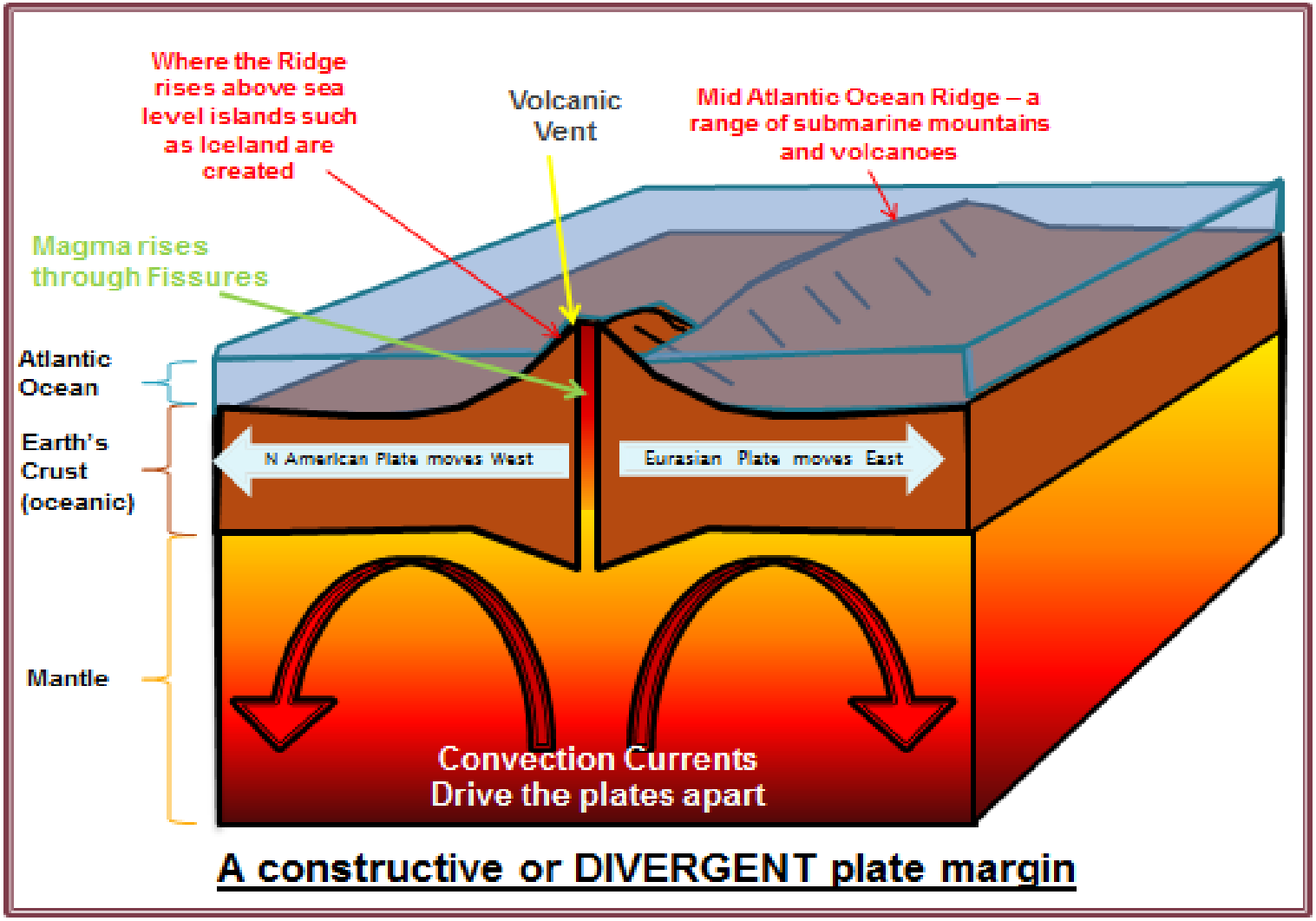
Convergent



Transform

1. CONSTRUCTIVE OR DIVERGENT MOVEMENTS

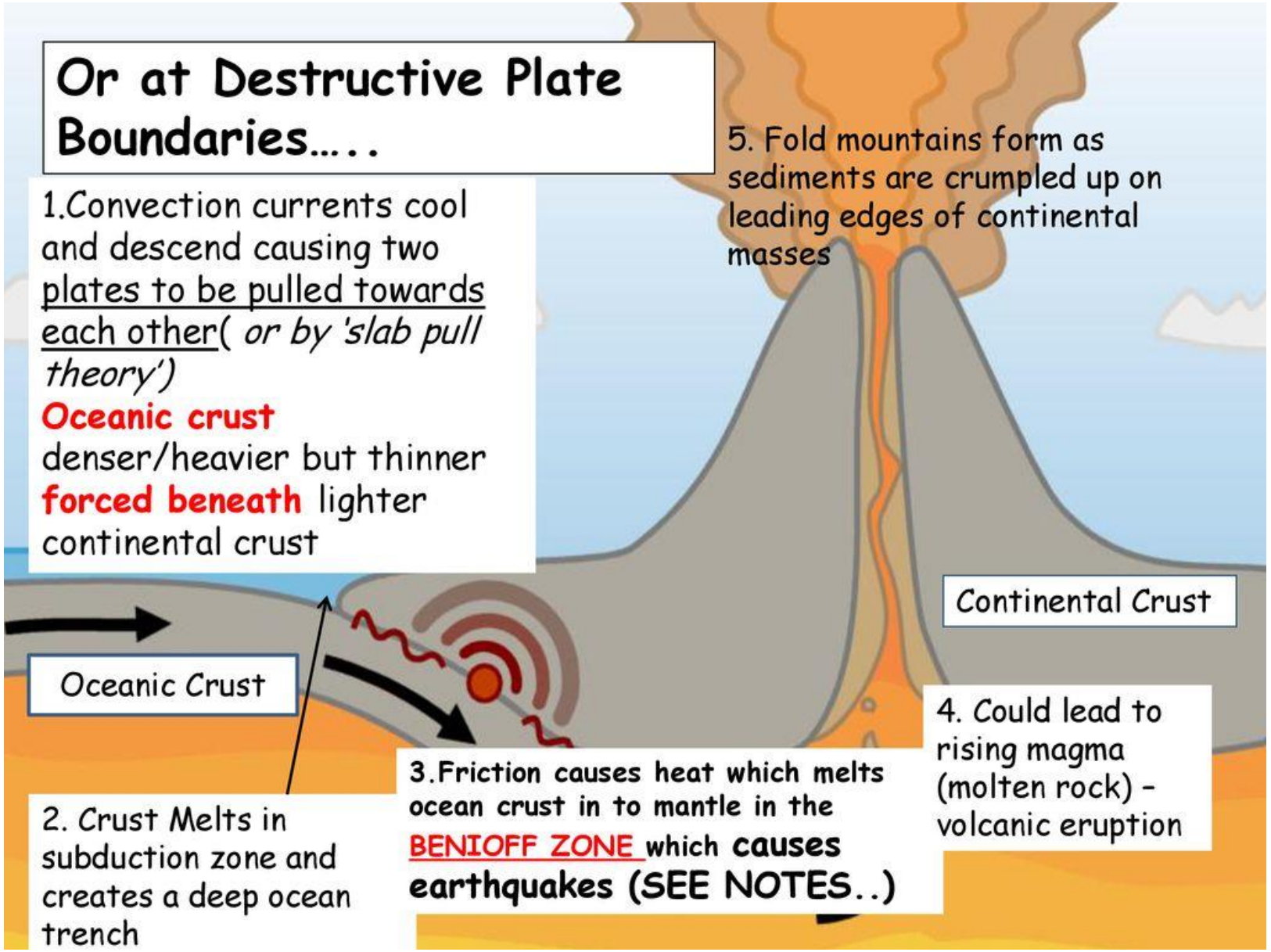
- Two plates are moving apart from each other.
- New magma from the mantle rises to the surface to fill the gap.
- It is runny lava, in a non-violent way and forms new basaltic ocean crust (sea-floor spreading),
- This lava forms volcanoes, which appear above sea-level as volcanic islands (Shield or basic volcanoes).
- If two continental plates move away from each other, a rift valley forms as the central block of land drops down between the faults.



A constructive or DIVERGENT plate margin

2. DESTRUCTIVE OR CONVERGENT MOVEMENTS:

- An oceanic plate and a continental plate move towards each other because of convection currents in the mantle.
- Denser oceanic plate is subducted under the light continental plate (Subduction or slab pull).
- The subduction of oceanic plate leads to formation of an ocean trench (surface of subduction zone coincides with ocean trenches).
- Ocean trench: A depression of the ocean floor parallel to destructive plate boundary (eg., Mariana Trench in Pacific Ocean – 11km depth called Challenger Deep).
- The heat produced by friction turns the descending plate into magma which starts to rise and erupt through either **explosive composite volcano** or **acidic volcano**.
- The magma that rises upwards and erupts at the surface and forms a chain of volcanic islands called an island arc.
- If two continental plates move towards each other, this is called a **collision zone**. The sediments between the two plates are squeezed together and pushed upwards to form Himalayas (fold mountains).


Or at Destructive Plate Boundaries…..
1.Convection currents cool and descend causing two plates to be pulled towards each other(or by 'slab pull theory')
Oceanic crust denser/heavier but thinner forced beneath lighter continental crust
5. Fold mountains form as sediments are crumpled up on leading edges of continental masses
Continental Crust
Oceanic Crust
4. Could lead to rising magma (molten rock) – volcanic eruption
3.Friction causes heat which melts ocean crust in to mantle in the BENIOFF ZONE which causes earthquakes (SEE NOTES..)
2. Crust Melts in subduction zone and creates a deep ocean trench

3. CONSERVATIVE MOVEMENTS:

- No plate is destroyed or created. The plates slide past each other.
- They may be moving at different speeds
- Stresses built up which are released by occasional sudden plate movements
- Friction caused by rock against rock forms earthquakes

CONSERVATIVE PLATE MOVEMENT

- A transform plate movement is one where two plates slide laterally past each other.
- This movement is not smooth due to <u>friction</u> between the rocks of the two plates.
- When there is sufficient buildup of pressure, rocks in the plates break and get jerked apart. This results in earthquakes.

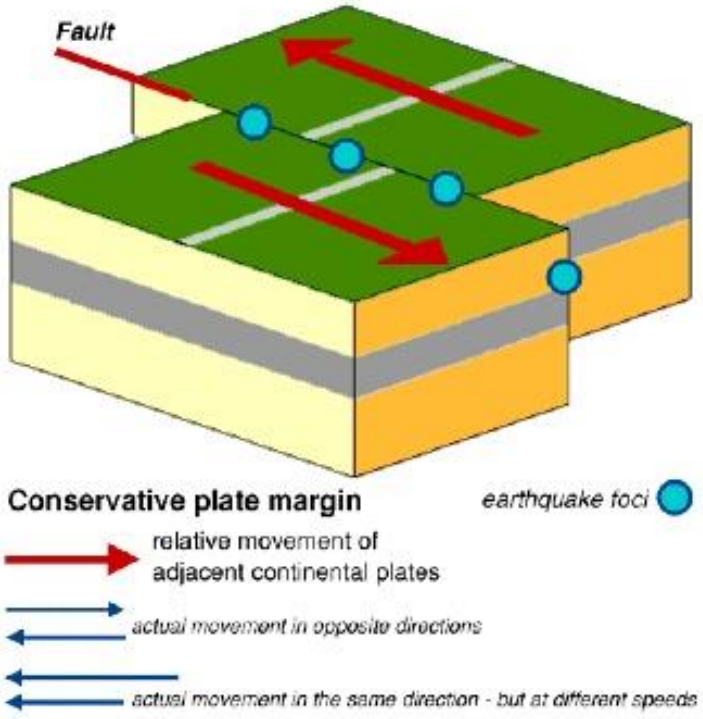
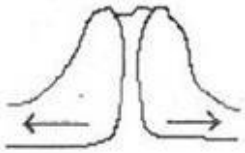
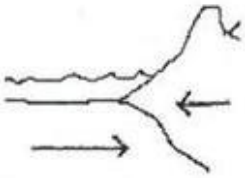
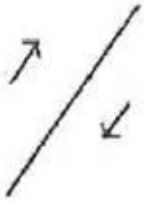
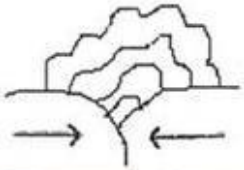


Plate boundaries and related features

Plate Boundary	Diagram	Description	Example	Stress type	Features
Constructive /divergent		**Constructive plate boundaries occur when** two plates move away **from each other**	**North American and** Eurasian **Plate**	Tension	•Earthquake •Ocean ridges •volcanoes
Destructive (Subduction zones)		**Destructive plate boundaries occur when an oceanic plate is forced under (or subducts) a continental plate**	**Pacific Plate and the Eurasian Plate**	Compression	•Earthquake •Oceanic trenches •Volcanoes **Destructive with two oceanic plates** •Earthquake •Oceanic trenches •Volcanoes •Island arcs
Conservative (transform)		**Conservative plate boundaries occur when two plates slide past each other.**	**North American Plate and the Pacific Plate**	Shearing	•Earthquake •Faulting
Collision		**Collision plate boundaries occur when two continental plates move towards each other.**	**Indo-Australian and the Eurasian Plate**	Compression	•Earthquake •Fold mountains

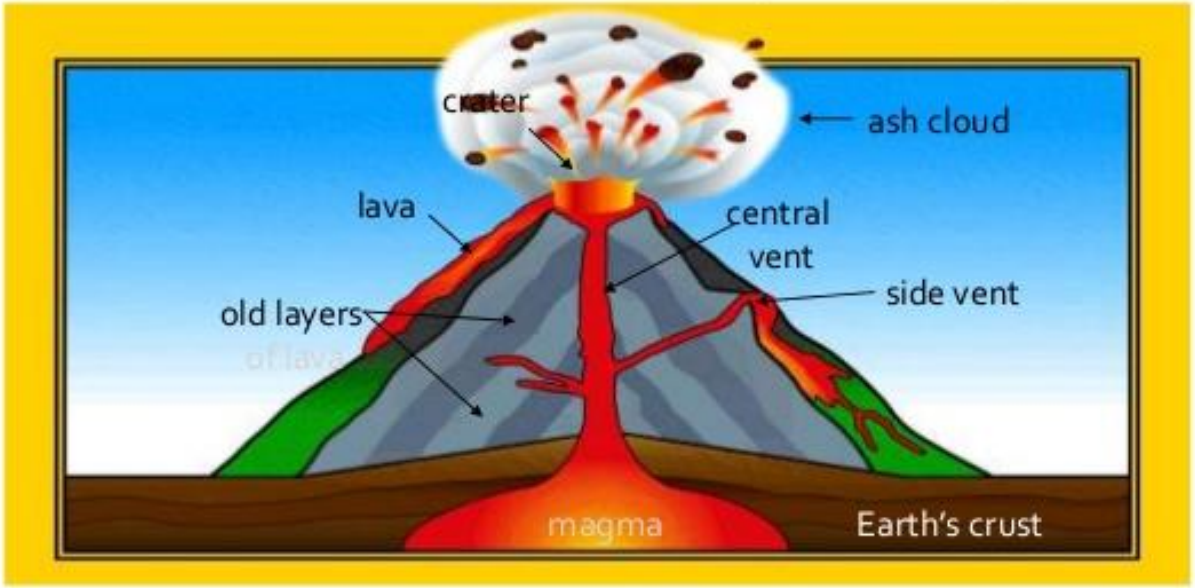
CHARACTERISTICS OF EARTH QUAKES

- **Focus**: where the Earthquake begins underground.
- **Epicentre**: point on the surface above the focus.
- **Seismometer**: an instrument used to measure the magnitude of an Earthquake (on the Richter scale).
- **During an earthquake**: Faults or cracks may appear on the Earth's surface leading to liquefaction (loose sediments with a high water content behave like a liquid).
- **A tsunami**: is created if an earthquake occurs under the sea or in a coastal area.
- **Factors that affect the impact of an Earthquake:**
  - Location of the epicentre;
  - Time of the Earthquake;
  - Geology of the area;
  - Relief of the area;
  - Severity of aftershocks;
  - Level of development of human settlement;
  - Population density;
  - Building density and strength

Richter Magnitude	Earthquake effects
0-2	Not felt by people
2-3	Felt little by people
3-4	Ceiling lights swing
4-5	Walls crack
5-6	Furniture moves
6-7	Some buildings collapse
7-8	Many buildings destroyed
8-Up	Total destruction of buildings, bridges and roads

CHARACTERISTICS OF VOLCANOES

- Volcano is a vent in the earth's crust through which hot lava and volcanic gases erupts



Two types of volcanic activity:

- **Intrusive,** when magma cools underground to form igneous rocks
- **Extrusive,** when magma flows out onto the Earth's surface as lava

Volcano: Hole or crack through which magma erupts onto the surface.

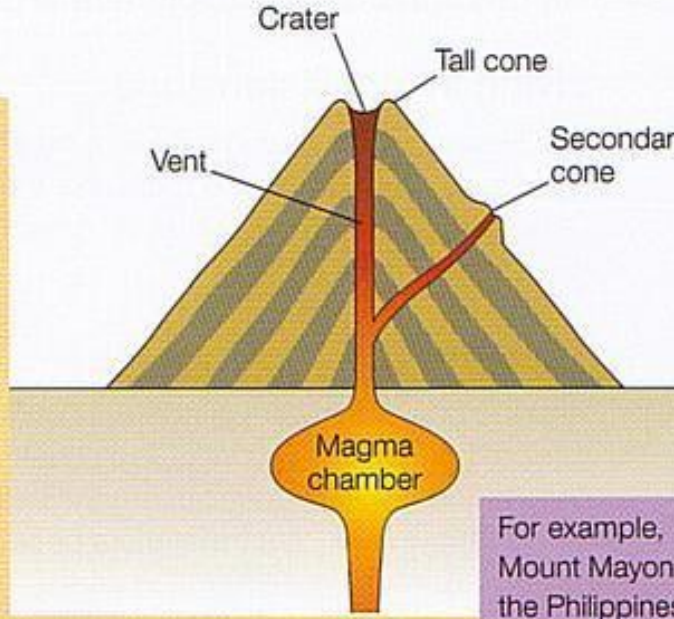
- **Pyroclastic Material:** If the magma has high gas content and high viscosity, the gas will expand in an explosive fashion and break the liquid into clots that fly through the air and cool along their path through the atmosphere. Alternatively, it blasts out solid pieces of rock. All of these fragments are referred to as Pyroclasts = hot, broken fragments.
- **Lahars (Volcanic Mudflows):** A volcanic eruption usually leaves lots of loose unconsolidated fragmental debris. When this loose material mixes with water from rainfall, melting of snow or ice, or draining of a crater lake, a mudflow results. Volcanic mudflows are called ***lahars***.

Volcanoes

There are two main types of volcano.

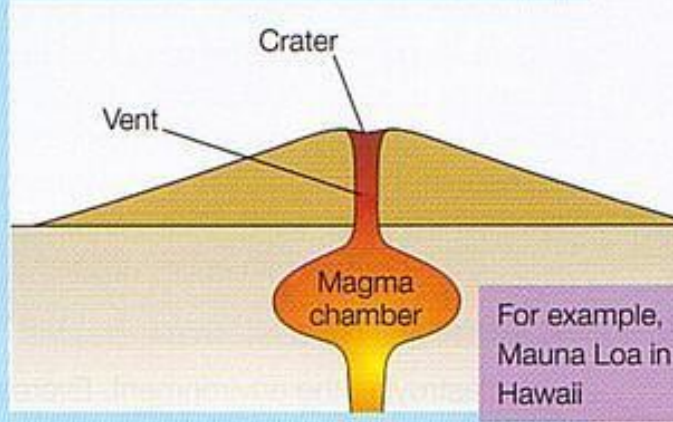
Composite volcanoes

- They're found at destructive plate margins. When the oceanic plate sinks into the mantle and melts, it forms magma. Magma mixed with sea water then rises up through cracks in the Earth's crust and erupts at the surface – forming volcanoes (page 11).
- Composite volcanoes have steep sides, and are made up of alternate layers of ash and lava.
- The lava is sticky, so it doesn't flow far. It's also acidic.
- Eruptions can be violent – expelling steam, ash, lava and rock – but they don't happen very often.



Shield volcanoes

- They're found at constructive plate margins. As the two plates move apart, magma rises up from the mantle. Some magma is forced to the surface through a vent – forming a volcano.
- Shield volcanoes have a wide base and gently sloping sides.
- The lava is runny and flows a long way. It's also basic (that's the opposite of acidic).
- There can be frequent eruptions, but they're not violent.



Tropical cyclones

- Cyclones are found in Indian Ocean, hurricanes in the Atlantic Ocean, typhoons in the western Pacific Ocean. (The only difference between a hurricane, a cyclone, and a typhoon is the location where the storm occurs.)
- Tropical cyclones-large areas of very low pressure with wind speeds of over 119 km/hr.
- Saffir-Simpson hurricane wind scale – wind speed on a scale of 1 to 5.
  - Category 1 – speeds between 119 & 153km/hr
  - Category 5 – Speeds over 252 km/hr

Causes of tropical cyclones:

- Ocean surface temperature of at least 27°C.
- Warm water provides the energy to evaporate more water, that rises, condenses, releasing huge amounts of energy.
- Warm water should be at least 60 m deep in ocean.
- These conditions must occur between 5° and 20° north and south to have sufficient Coriolis effect (rotation of earth), making the air spin.
- Very little wind shear (change in wind speed or direction) allows the vertical development of the storm

Distribution of tropical cyclones:

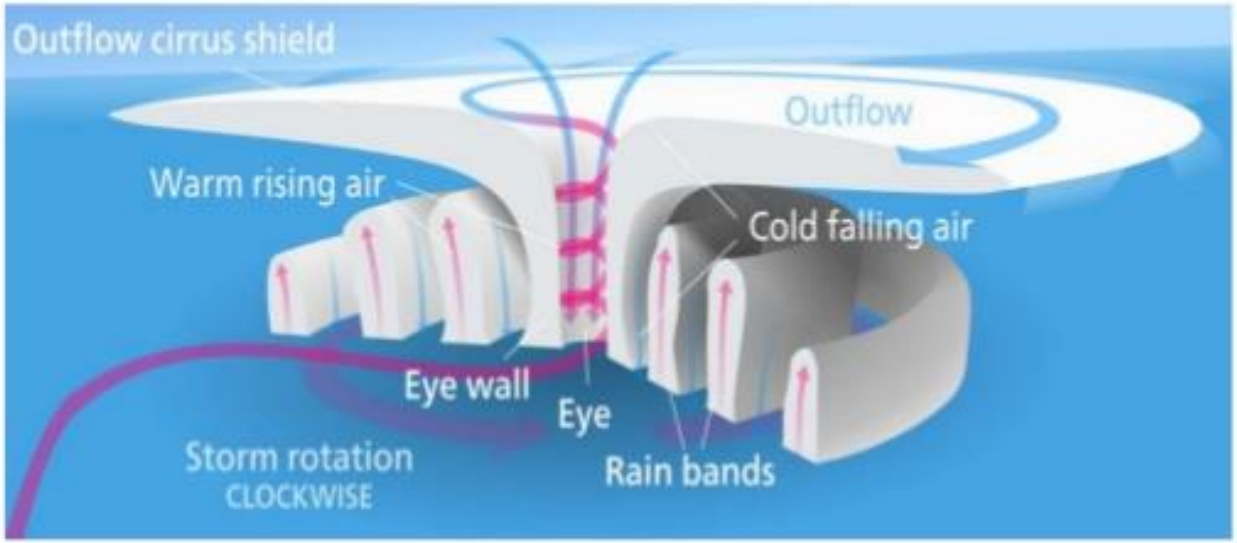
- Between 5° and 20° north and south.
- They do not form on the equator because the Coriolis effect there is 0.
- The air at the equator tends to flow straight from high pressure to low pressure, without any rotation.

Characteristics of tropical cyclones:

1. Sky becomes cloudy, wind speed increases, rain with sunny intervals.
2. Air pressure falls, wind speed increases with very heavy rainfall. This is the eyewall or vortex.
3. In the eye of the storm, the sky is clear, winds are light and little rain.
4. After the eye has passed, heavy rain and strong winds follow.
5. Finally, wind speed and rainfall decreases.

Cumulonimbus is a dense, towering vertical cloud, forming from water vapor carried by powerful upward air currents.

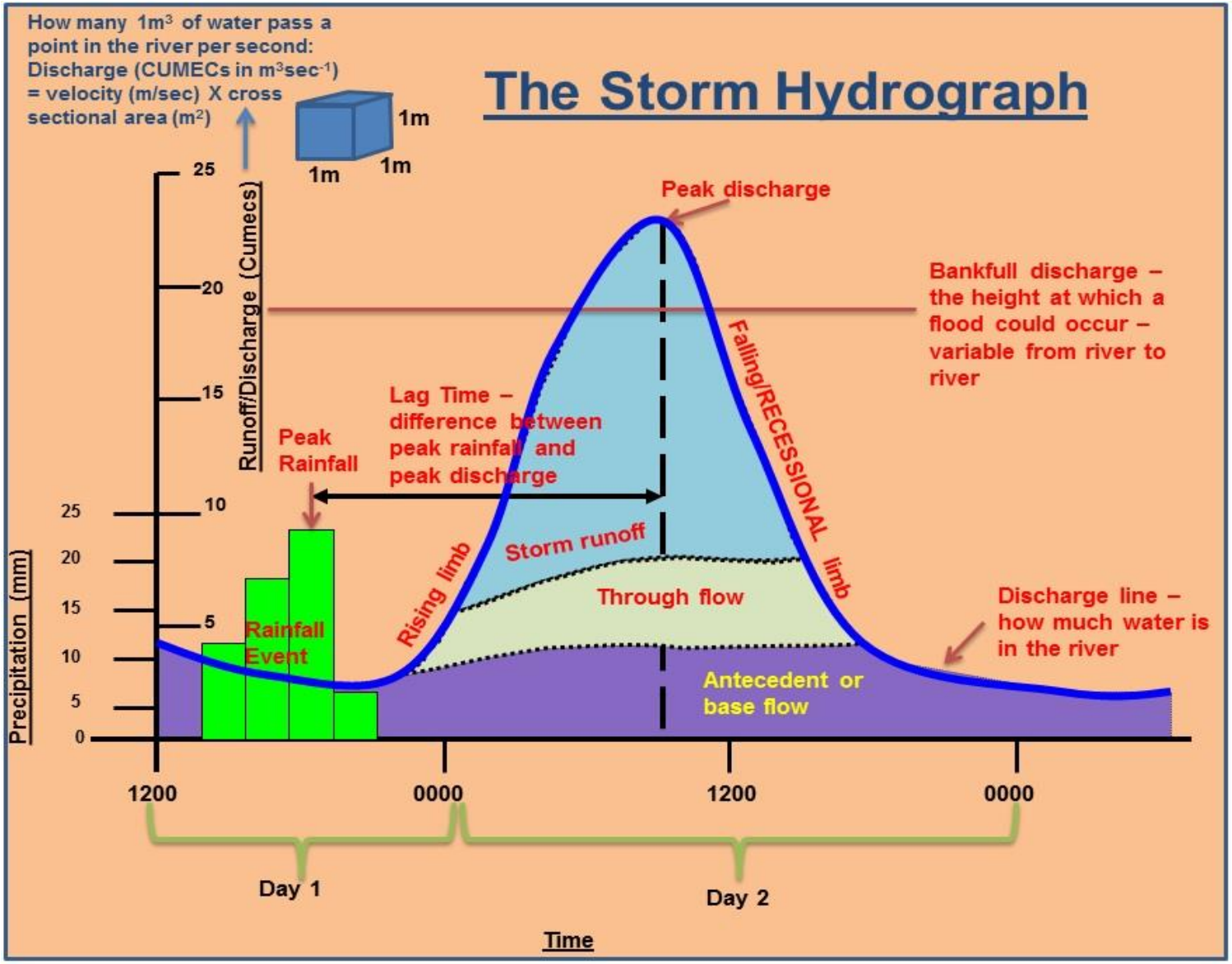
Tropical cyclone structure



- **Eye:** A region 30-65 km in diameter found at the center where skies are often clear, winds are light, and the storm's lowest pressure readings are obtained.
- **Eye Wall:** A ring of cumulonimbus clouds that swirl around the eye. The heaviest precipitation and strongest winds are found here.
- **Spiral Rainbands:** Bands of heavy convective showers that spiral inward toward the storm's center. Thunderstorms are observed here.

Causes and impacts of flooding-

- Flooding occurs when the discharge of a river exceeds the river channel's capacity and water overflows onto the floodplain.
- Storm hydrograph: **A storm hydrograph is a way of displaying how the discharge of a river can change over time in response to a rainfall event.**


How many 1m³ of water pass a point in the river per second: Discharge (CUMECs in m³sec⁻¹) = velocity (m/sec) X cross sectional area (m²)
1m
1m
1m
The Storm Hydrograph
Runoff/Discharge (Cumecs)
25
20
15
10
5
Peak discharge
Bankfull discharge – the height at which a flood could occur – variable from river to river
Lag Time – difference between peak rainfall and peak discharge
Peak Rainfall
Falling/RECESSIONAL limb
Rising limb
Storm runoff
Through flow
Precipitation (mm)
25
20
15
10
5
0
Rainfall Event
Discharge line – how much water is in the river
Antecedent or base flow
1200
0000
1200
0000
Day 1
Day 2
Time

- Antecedent soil moisture: The amount of water in the soil before a rainfall event.
- Base flow: Ground water (Very slow), Through flow: Movement of water through soil, Overland flow: Runoff water
- Storm hydrographs show how quickly a river responds to a rainfall event; the shorter the lag time and the steeper the rising limb, the quicker the water will reach the channel.
- Flooding is predominantly a natural event.
- The main causes are weather, soil and rock type, relief and the effects of other hazards such as volcanoes, earthquakes and cyclones.
- Humans can make flooding more likely through deforestation, urbanization, agriculture, and climate change.
- Flooding is more likely where the ground is impermeable, antecedent moisture is high, and gradients are steep.

PHYSICAL CAUSE	IMPACT
HEAVY RAINFALL	• Reduces the infiltration capacity of the soil; • Increase in overland flow.
PROLONGED RAINFALL	• Saturates the soil; • Causes the water table to rise, reducing infiltration capacity.
SNOWMELT	• Overland flow occurs due to rapid snowmelt.
LAND RELIEF	• Steeper gradients lead to faster overland flow ∴ water has little time to infiltrate.
SATURATED SOIL	• The more saturated the soil is (before the rainfall), lesser infiltration and more overland flow.
STORM SURGES, TSUNAMIS	• Flooding of low-lying coastal areas.

HUMAN CAUSE	IMPACT
DEFORESTATION	• Reduces interception and infiltration.
CULTIVATION	• Ploughing down rather than across slopes increases the water flow.
URBANISATION	• Concrete and tarmac are impermeable surfaces (no infiltration ∴ high overland flow).
CLIMATE CHANGE	• Global warming may lead to rise in sea levels and more rainfall in some areas.

Causes of drought: -

Droughts occur when there is abnormally low rainfall for an extended period of time. This means that a desert would not be considered in drought unless it had less rainfall than normal, for a long period of time. Droughts can last from weeks to months and even years.

Droughts can occur all over the world. However, there is a link between drought and some climate patterns.

- A lack of water vapour in the atmosphere means there is less precipitation and more chance of drought. High-pressure systems reduce evaporation and moisture in the atmosphere.
- **El Niño** – as the surface temperature of the Pacific Ocean around the central South American coast **increases**, storm patterns are disrupted. This phenomenon is thought to create droughts in Indonesia and Australia.
- **La Niña** - as the surface temperature of the Pacific Ocean around the central South American coast **decreases**, storms are again disrupted and North and South America are prone to droughts.

Impact of human activity on drought:-

It is predicted that climate change will cause some places around the world to get hotter, which will increase evaporation and some to receive less rainfall, both increase the risk of drought.

Other human activities can increase the impact of drought:

- **Agriculture** – using large amounts of water to irrigate crops removes water from lakes, rivers and groundwater. Some crops require more water than others, eg cotton.
- **Dam building** – large dams can be built across a river to produce electricity and store water in a reservoir. This can reduce river water flowing downstream and cause drought below the dam.
- **Deforestation** – removing trees can reduce the amount of water stored in the soil as rain tends to fall and wash off the land as surface run-off. This leaves the ground vulnerable to erosion and desertification which can lead to drought.

Impacts of natural hazards:-

- **Impacts of tectonic events:**
  - Damage to buildings and infrastructure;
  - Fires from ruptures of gas pipes;
  - Tsunamis hit coastlines;
  - Landslides cover buildings and roads;
  - Destruction of farmland, leading to starvation;
  - Loss of wildlife habitats;
  - Water-related diseases because victims are in temporary accommodation with no sanitation or clean water;
    - Water is also contaminated by broken sewage pipes or untreated sewage.
  - Loss of life;
  - Trauma, poor mental health;
  - Financial losses when repairing the damage.

- **Impacts of tropical cyclones:**
  - Flooding from storm surges and heavy rainfall;
  - Loss of life;
  - Damage to buildings and infrastructure;
  - Disruption of electricity, transport and water supply;
  - Water-borne diseases;
  - Economic loss as production is halted;
  - Damage to crops, food shortages and loss of export earnings;
  - Loss of wildlife habitats.
- **Impacts of flooding:**
  - Loss of life;
  - Damage to buildings and infrastructure;
  - Contamination of water supplies leading to disease;
  - Loss of crops and livestock leading to food shortages;
  - Deposition of silt from the flood waters;
  - Recharge of groundwater stores;
  - Rivers may change course;
  - Financial losses when repairing the damage.

Impacts of droughts:

- Water sources dry up, forcing people to travel long distances to fetch water;
- Decline in crop yields;
- Loss of crops, livestock, plants and wildlife;
- Decrease in land prices as production declines and farmers lose money;
- Migration from rural to urban areas;
- Unemployment;
- Increase in food prices;
- Health problems due to malnutrition;
- Soil erosion, leading to desertification;
- Increased risk of wildfires and poor air quality;
- Conflicts over water usage and food.

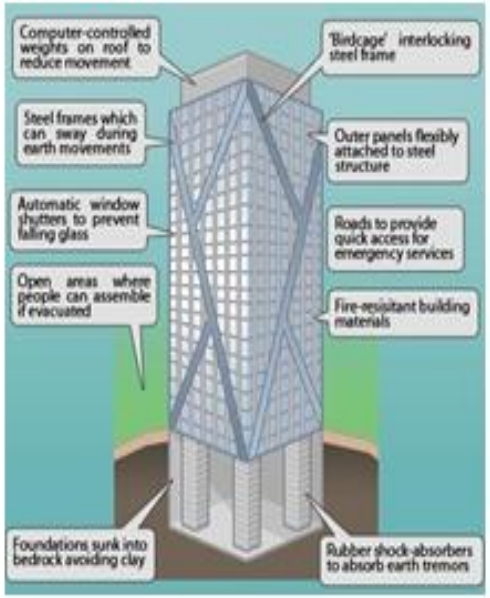
Strategies to manage the impact of natural hazards:-

- **Volcanoes:**
  - **Prediction:**
    - Seismometers can be used to monitor tremors caused by rising magma;
    - Satellites using heat-seeking cameras can be used to monitor increasing ground temperatures;
    - Tiltmeters (measure very subtle changes in the surface of the Earth as magma accumulates) and GPS can be used to monitor changes in volcano shape;

    - Emissions of steam and gas (sulfur dioxide) can be monitored.
  - **Preparation and protection:**
    - Volcano hazard map (study past eruptions);
    - Lava diversion channels and lava barriers ;
    - Spraying lava with water;
    - Halting lava advance by dropping concrete slabs into the flow;
    - Building reinforcements (sloping roofs to protect against ashfall).

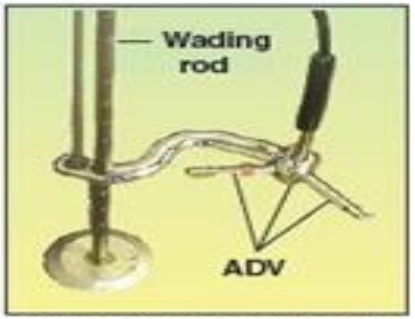
- **Earthquakes**:
  - **Prediction**:
    - Monitor tremors (using seismometers), groundwater levels and radon gas;
    - Epicentres and frequencies of past events can be mapped to check if a pattern is developing;
    - Measurement of local magnetic fields;
    - Hazard zone map can be drawn (geological info and ground stability);
    - Unusual animal behaviour.

- **Preparation and protection:**
  - Earthquake-proof or aseismic buildings. Older buildings can be modernised;
  - Smart meters to switch off gas supplies, preventing fires;
  - **Land-use planning**: important services (schools, hospitals) must be built in low-risk areas.



- **Tropical cyclones:**
  - **Prediction:**
    - Tracked using satellites.
  - **Preparation and protection:**
    - Cyclone shelters;
    - Embankments along the coast;
    - Preserve mangrove swamps to absorb the energy of storm surges.

- **Flooding:**
  - **Prediction:**
    - Monitoring the amount of rainfall and river discharge using an ADV;
    - Using the features of the drainage basin and type of storm to determine the severity of the flood.



Acoustic Doppler Velocimeter (ADV) mounted on a rod.

  - **Preparation and protection:**
    - Hard engineering projects (levees, flood barriers and dams);
    - Soft engineering projects (afforestation and storage basins);

    - Increasing the river channel (clearing vegetation);
    - Land-use planning to restrict development on floodplains;
    - Use of sandbags and pumps;
    - Adapt houses to position power sockets 1.5 m above ground level to prevent electrocution.

- **Droughts:**
  - **Prediction:**
    - Monitoring precipitation and temperature.
  - **Preparation and protection:**
    - Increase water supplies (dams, reservoirs, wells, percolation ponds, aquifers, pumps, water transfer by pipeline and desalination);

    - Water conservation (storage tanks, spray irrigation, drought-tolerant crops, recycling water and reducing deforestation);
    - Agricultural improvements (shelterbelts to decrease wind and evaporation, bunds to increase infiltration and fencing to control overgrazing);
    - Government stockpiling supplies of water, food and medicine.

Opportunities presented by natural hazards:-

- Individuals may want to be near family and friends.
- Confidence in prediction, preparation and protection.
- Employment opportunities e.g. tourism.
- No choice in moving if there is pressure on land or if it is too expensive to move.
- After a volcanic eruption, fertile soils are created that produce high crop yields.
  - The scenery can be spectacular;
  - Geothermal energy can be obtained easily;
  - Possibility of mining minerals such as sulfur, diamonds and gold.
- Living near rivers may provide a source of food, water for drinking and irrigation.
  - Communications may be easier;
  - Flat land on either side is available for building on.

Thank you