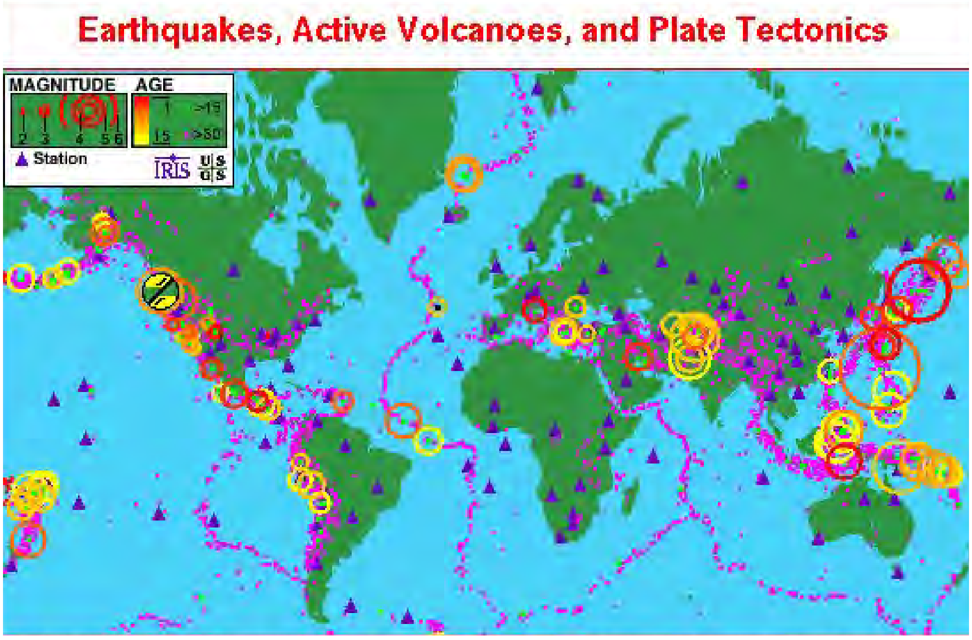
Edexcel Geography A-level

Tectonic Processes and Hazards

Detailed Notes

The Global Distribution of Hazards

- → A **hazard** is a potential threat to human life and property.
- → A natural hazard can be either **hydro-meteorological** (caused by climatic processes) or **geophysical** (caused by land processes).



- → Geophysical hazards occur **near plate boundaries**. These plates move at different speeds and directions which can cause collisions, earthquakes and volcanic activity as shown in the map above.

- → Earthquakes can also occur near the middle of plates (called **intra-plate**). The causes of this are not fully understood but it is assumed that plates have **pre-existing weaknesses** which become reactivated, forming seismic waves. For example, an intraplate earthquake may occur if solid crust, which has weakened over time, cracks under pressure.

- → **Volcanic hotspots**, such as the Ring of Fire, are also situated amongst the centre of pates. This is a **localised area of the lithosphere** (Earth's crust and upper mantle) which has an unusually high temperature due to the upwelling of hot molten material from the core. (First theorised by **Tuzo Wilson** in 1963)

- → At hotspots, such as the Hawaii hotspot, **magma** rises as plume (hot rock).

- → Usually, the most powerful earthquakes occur at **convergent or conservative** boundaries.

OFZ (Oceanic Fracture Zone) – This is a belt of activity through the oceans and along the mid-ocean ridges through Africa, the Red Sea, the Dead Sea

CFZ (Continental Fracture Zone) – This is a belt of activity along the mountain ranges from Spain through the Alps to the Middle East and to the Himalayas.

Tectonics Trends since 1960

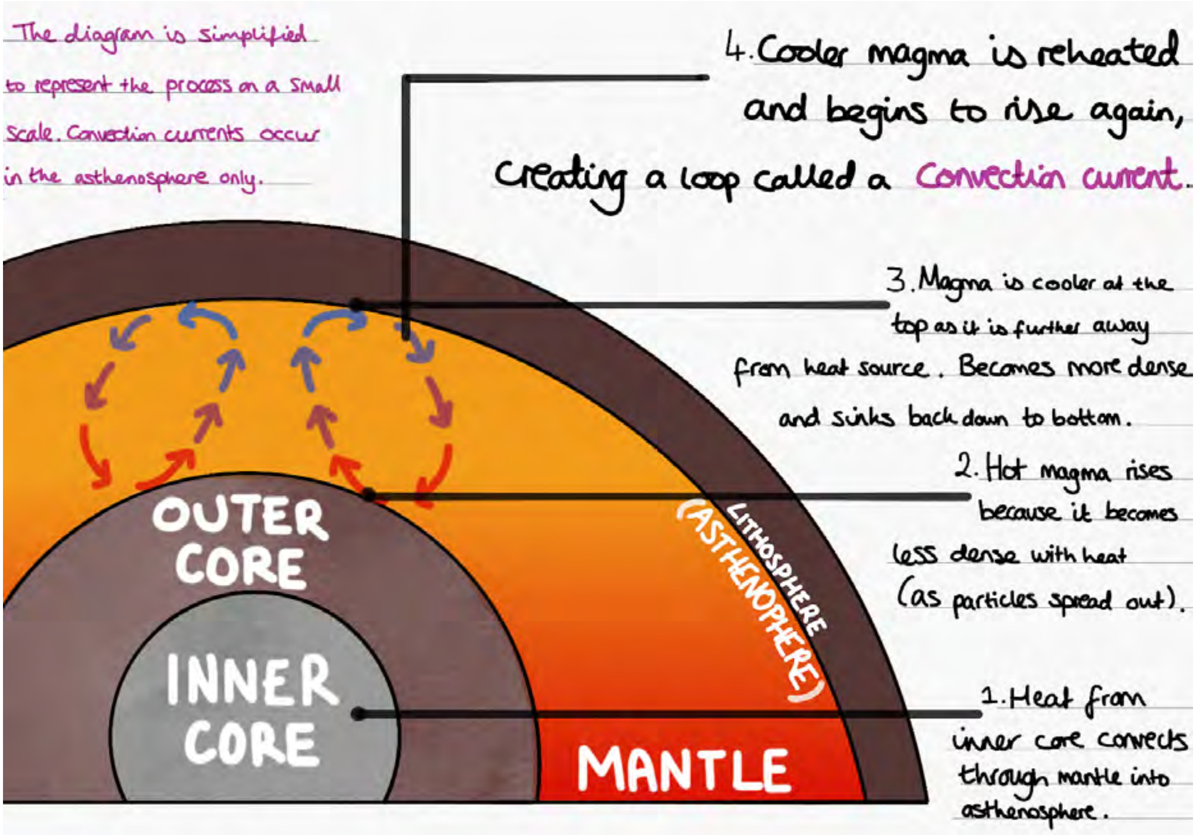
- The total number of **recorded hazards** has **increased.**
- The number of **fatalities** has **decreased,** but there are some spikes during **mega disasters**.
- The **total number** of people being **affected** by tectonic hazards is **increasing**, due to population growth.
- The **economic costs** associated with hazards and disasters has **increased** significantly. This is partly due to increases in development as infrastructure in more developed countries costs more to repair. Also, increasing number of **insurance policies**, especially in developed countries, heightens the costs.

Reporting disaster impacts (e.g. fatalities) is very difficult and controversial for several reasons:

- Depends on whether you look at the **direct deaths** so those killed in the disaster straight away or **indirectly** by looking at how many people died of diseases that spread after the disaster. Some impacts take time to become apparent.
- The **location** is important as rural and isolated areas are hard to reach and so it may be hard to collect data from them. Similarly, data may be difficult to collect in areas with very high population densities.
- **Different methods** may be used by different organisations so as a result different sources may quote different numbers of deaths and injuries
- The number of deaths quoted by a government could be subject to **bias**. For example, during the 2004 Indian Ocean tsunami, the Burmese government claimed there were 0 deaths Burma. This may be to try and show that the government is doing a good job in terms of aid, protection etc.

Tectonic Theory

Characteristics of the Earth's Structure



The Earth consists of **four** sections:

- **Crust** - Also known as the **lithosphere**. The uppermost layer of the Earth which is thinnest, least dense and lightest. Oceanic crust is only **7km thick,** whereas continental crust can be up to **70km thick**.
- **Mantle** - May also be called the **asthenosphere**. Largely composed of silicate rocks, rich in iron and magnesium. The mantle is **semi-molten** and a **temperature gradient** (towards the core) generates **convection currents**. This causes to the circulation of the mantle and may contribute to the lithosphere's plate tectonic movement. The mantle is at a depth from **700km to 2890km** below the crust.
- **Outer Core** - Dense, **semi-molten** rocks containing iron and nickel alloys. At a depth of **2890km to 5150km** below the Earth's surface.
- **Inner Core** - Similar composition to the outer core. It's over **5150km** below the Earth's crust. The inner core is solid due to the **extreme pressures** it experiences. The core's high temperature is a result of:
  - **primordial heat** left over from the earth's formation
  - radiogenic heat produced from **radioactive decay**

Different Plate Boundaries

At plate boundaries, different plates can either move **towards each other** (**destructive** plate margin), **away from each other** (**constructive** plate margin), or **parallel** to each other (**conservative** plate margin). Different landforms are created in these different interactions. This spider diagram outlines what landforms and processes occur at the boundaries.

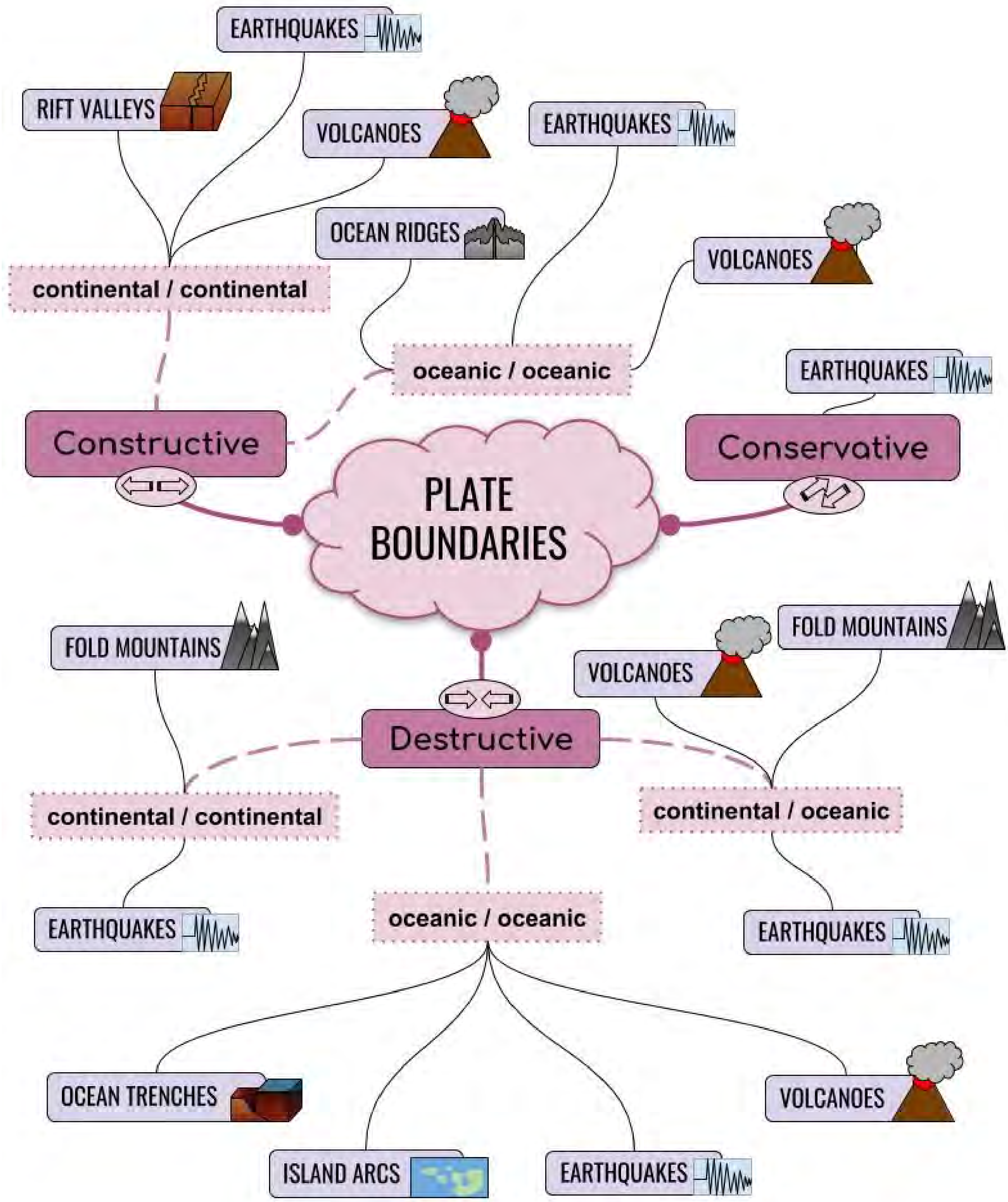
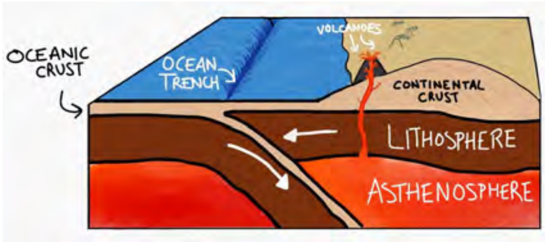
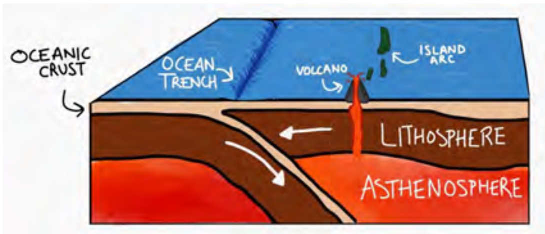
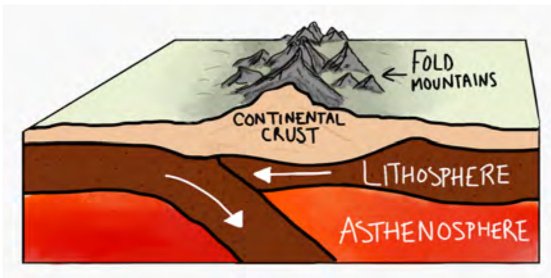
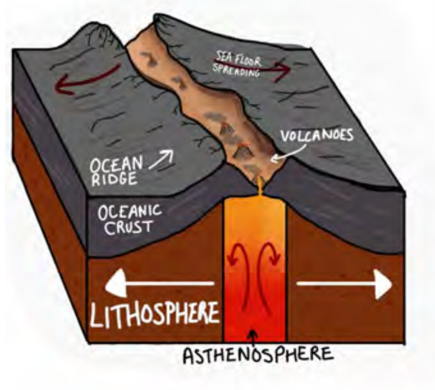
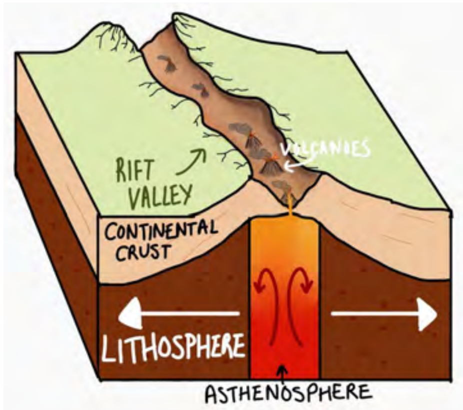


Plate Boundaries

Destructive plate boundaries	
Continental and oceanic: • Denser oceanic plate **subducts** below the continental. • The plate subducting leaves a deep **ocean trench**. • The oceanic crust is melted as it subducts into the asthenosphere. • The extra magma created causes **pressure** to build up. • Pressurised magma forces through weak areas in the continental plate • Explosive, high pressure volcanoes erupt through the continental plate, known as **composite volcanoes**. • **Fold mountains** occur when sediment is pushed upwards during subduction.	
Oceanic and oceanic: • Heavier plate **subducts** leaving an ocean trench. Fold mountains will also occur. • Built up pressure causes **underwater volcanoes** bursting through oceanic plate. • Lava cools and creates new land called **island arcs**.	
Continental and continental: • Both plates are not as dense as oceanic so lots of **pressure builds.** • Ancient oceanic crust is subducted slightly, but there is **no subduction of continental crust.** • **Pile up** of continental crust on top of lithosphere due to pressure between plates. • **Fold mountains** formed from piles of continental crust.	

Constructive plate boundaries	
Oceanic and oceanic: ● Magma rises in between the **gap left by the two plates separating**, forming new land when it cools. ● Less explosive underwater volcanoes formed as magma rises. ● **New land** forming on the ocean floor by lava filling the gaps is known as **sea floor spreading** (as the floor spreads and gets wider).	
Evidence There is sufficient evidence to prove plate movement, and **seafloor spreading** (theorised by **Harry Hess** in the 1940s) provides some of this proof. **Paleomagnetism** is the study of rocks that show the magnetic fields of the Earth. As new rock is formed and cools the magnetic grains within the rock align with the magnetic poles. Our poles (North and South) **switch** periodically. Each time these switch the new rocks being formed at plate boundaries **align in the opposite direction** to the older rock. On the ocean floor either side of constructive plate boundaries, Geologists observed that there are **symmetrical bands** of rock with **alternating bands of magnetic polarity**. This is evidence of seafloor spreading.	
Continental to continental: ● Any land in the middle of the separation is forced apart, causing a **rift valley**. ● Volcanoes form where the magma rises. ● Eventually the gap will most likely fill with water and separate completely from the main island. ● The lifted areas of rocks are known as **horsts** whereas the valley itself is known as a **graben**.	
There are further forces influencing how convergent boundaries occur - **Ridge push:** The **slope** created when plates move apart has **gravity acting upon it** as it is at a **higher elevation**. Gravity pushes the plates further away, widening the gap (as this movement is influenced by gravity, it is known as **gravitational sliding**). **Slap pull:** When a plate **subducts**, the plate sinking into the mantle **pulls the rest of the plate** (slab) with it, causing further subduction.	

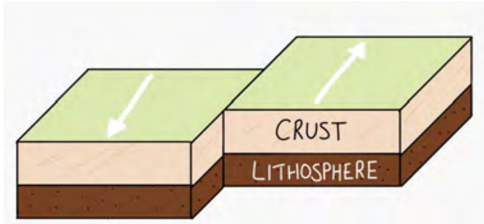
Conservative plate boundary	
Between any crust, the **parallel plates** move in **different directions** or at **different speeds**. No plates are destroyed so no landforms are created. When these plates move, a lot of pressure is built up. On oceanic crust, this movement can displace a lot of water. On continental crust, **fault lines** can occur where the ground is cracked by the movement.	

Plate Movements

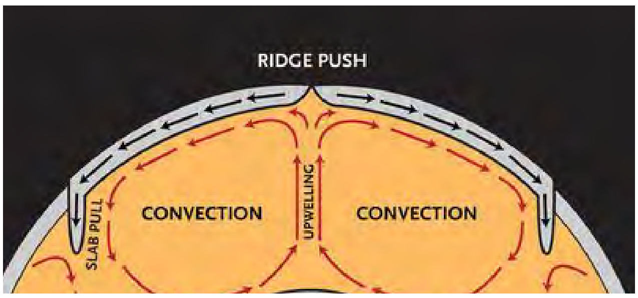
There are two different types of crust and they consist of different rocks:

- **Oceanic** – Low density of rock, mainly basalt, thin, newly created.
- **Continental** – High density of rock, mainly granite, thick, old.

The **density** of the plate will determine whether the plate subducts or is forced upwards. This will determine the **landscape** and **hazards** the margin is vulnerable to.

There are different **mechanisms** that could cause plate movement:

- **Mantle Convection** - Radioactive elements in the core of the Earth decay which produce a lot of **thermal energy**. This causes the lower mantle to heat up and rise, as the magma rises it cools down and becomes more dense and begins to sink back down to the core. These are **convection currents**. These convection currents push the plates.
- **Slap Pull** - Old oceanic crust (which is the most dense plate) will submerge into the mantle. This pulling action drags the rest of the plate with it. (It was first theorised by **Dan McKenzie**)



It is important to note that tectonic movement isn't fully understood. Previously, **convection currents** were thought to be the primary cause of plate movement. However, researchers now believe that **Slab Pull** is the **primary mechanism** for plate movement; convection currents seem too weak to move massively dense plates.

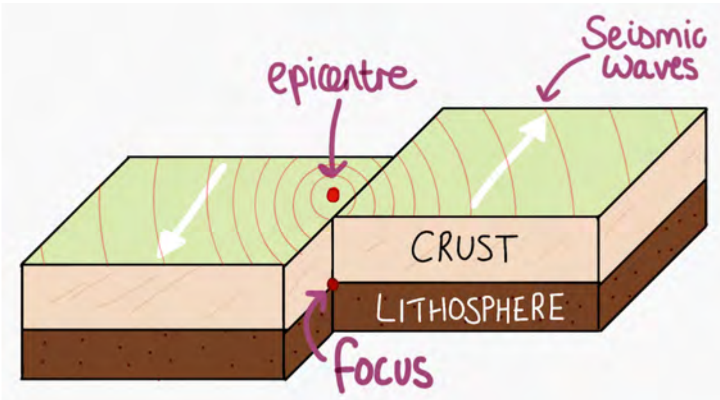
Earthquakes

Plates do not perfectly fit into each other, meaning they do not move in **fluid** motions. At all boundaries, plates can become stuck due to the **friction between plates**.

You can try this by moving **one palm** of your hand **against the other**, and it is clear that at some points there is more friction between irregularities and bumps, causing the hands to become stuck slightly.

When the plates are stuck, the **convection currents** in the asthenosphere continue to push, which builds the pressure. It builds so much that it cannot be sustained and the plates eventually **give way**. All of this pressure is released in a sudden movement, causing a **jolting motion** in the plates. This jolt is responsible for **seismic** movement spreading throughout the ground in the form of **seismic waves** (or shock waves).

The **focus** (or hypocentre) is the point underground where the earthquake originates from. The **epicentre** is the area above ground that is **directly above** the focus.



Seismic Waves

Primary -Travels through solids -Compressional -Vibrates in the direction of travel - Travels at 4-8 km/s	**Secondary** -Vibrate at right angles to direction of travel -Travels only through solid rocks -Travels at 2.5 - 4 km/hr
Love -Near to ground surface -Rolling motion producing vertical ground movement -Travels at 2-6 km/hr	**Rayleigh** -Vertical and horizontal displacement -Travels at 1-5 km/hr -Compressional

Secondary and Love waves are the most destructive as they have **large amplitudes**. Due to their different speeds, these different waves will hit a location at different times. The **aftershocks** that survivors feel are these different types of waves arriving after each other.

Intensity of waves will **decrease further from the epicentre**, as waves lose energy as they travel. However, this does not mean that impacts felt or damage caused will always decrease further from the epicentre as other factors affect a location's **vulnerability:** geology, geographical location (whether the earthquake occurs near the sea or intraplate), education of locals, durability of buildings, mitigation.

Secondary Hazards of Earthquakes

Soil Liquefaction

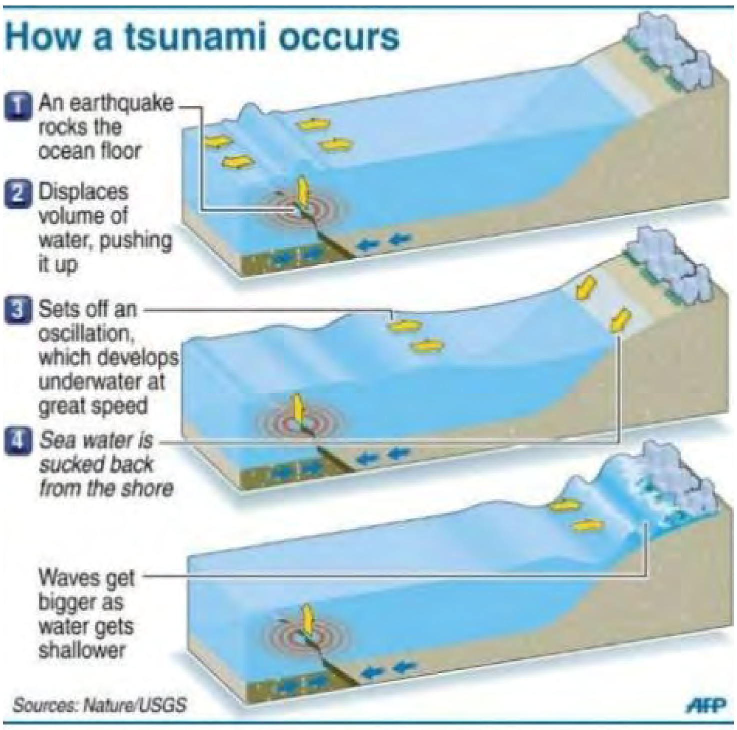
- Affects poorly compacted sand and silt.
- Water moisture within the soil separates from the soil particles and rises to the surface.
- This can cause the soil to behave like a liquid, which can cause building subsidence or landslides.

Landslides

- The shaking caused by the earthquake can weaken or damage cliff faces, hills and snow material.
- Unconsolidated material or loose rocks can collapse.
- Landslides can travel several miles and accumulate material on the way.
- Risk varies with topography rainfall, soil and land use.

Tsunamis

- When an oceanic crust is jolted during an earthquake, all of the water above this plate is **displaced**, normally upwards
- This water is then pulled back down due to gravity. The energy is transferred into the water and travels through it like a wave.
- The water travels fast but with a low **amplitude** (height).
- As it gets closer to the coast, the sea level decreases so there is friction between the sea bed and the waves.
- This causes the waves to slow down and gain height, creating a wall of water that is on average 10 feet high, but can reach 100 feet.



Tsunamis are generated generally in **subduction zones** at convergent plate margins. Most tsunamis are found along the Pacific ring of fire, hence the most vulnerable countries are often located in Asia or Oceania.

The impact of a tsunami depends on various human and physical factors

- **Population density** of area hit, if the population is higher than more people are likely to be affected
- **Coastal defences** (e.g. Tsunami waves)
- Duration of the event
- Wave amplitude and distance travelled
- Gradient of the **continental shelf**
- The shape of the land - **bays** will funnel and concentrate tsunami waves.
- **Warning & Evacuation** Systems
- Level of economic and human development

Volcanoes

Primary hazards, caused directly from the volcano, tend to have a **fast speed of onset**:

- **Lava flows** – Streams of lava that have erupted onto the Earth's surface. Fast flowing lava can be very dangerous which depends on the lava's **viscosity** (the explosivity and viscosity depends on **silicon dioxide** content)

- **Pyroclastic flows** – This is a mixture of hot dense rock, lava, ash and gases which move very quickly along the surface of the Earth. Due to their **high speeds**, pyroclastic flows are extremely dangerous and can cause **asphyxiation** for anyone unfortunately caught by the flow.

- **Tephra and ash flows** – When pieces of volcanic rock and ash are blasted into the air. This can cause serious **damage to buildings**, which can collapse under the weight of ash or tephra.

- **Volcanic gases** – Gases like **sulphur dioxide** and **carbon monoxide** are released into the atmosphere. Due to their potency, volcanic gases can travel long distances.

Secondary hazards occur as a result of the heat produced by the volcano:

- **Lahars** – Combination of **rock, mud and water** which travel quickly down the sides of volcanoes. These can occur when the heat of the eruption causes snow and ice to melt or alternatively when an eruption coincides with heavy rainfall.

- **Jokulhlaup** – Snow and ice in glaciers melt after an eruption which causes **sudden floods** that are very dangerous .

- **Acid rain** - caused when gases such as **sulfur dioxide** are released into the atmosphere.

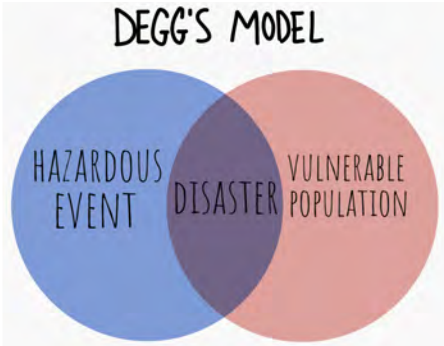
Classification and Theories of Tectonic Events

Disaster – A serious disruption of the functioning of a community or society involving human, material, economic and environmental losses which exceeds the ability of the affected community or society to cope using its own resources.

The **risk** a community faces from a natural hazard can be calculated from the equation below.

$$\text{Risk (R)} = \frac{\text{Hazard (H)} \times \text{Vulnerability (V)}}{\text{Capacity to cope (C)}}$$

How **developed** a country is significantly affects how **resilient** its population is and their **capacity to cope** with a hazard.



A place may be at high risk if:

- Their **capacity to cope** is low.
- They are quite **vulnerable.**
- The hazard is large/ high intensity.

Degg's Model

Hazards should not be confused with **natural disasters**. A disaster will only occur when a **vulnerable population** (one that will be significantly disrupted and damaged) is exposed to a hazard. Degg's model is a good representation of this concept. If the population is not vulnerable, the hazard will not have a significant effect, thus the event will not be **disastrous**.

Different **organisations** will define a hazard and disaster differently, based on their interests and what they believe is **most important**. For example, the United Nations Office for Disaster Risk Reduction (UNISDR) define a disaster as "a serious disruption of the functioning of a community or society involving widespread losses and impacts, which exceeds the ability of the affected community or society to cope with using its own resources."

There are other ways to classify a tectonic hazard, each measure having different successes and downfalls in correctly representing the magnitude and impact of a disaster:

- The **volume of people affected** - The International Disaster Database classifies a disaster as an event where more than 100 people are affected or more than 10 people die.
- **Economic cost** of the disaster - jobs lost, cost of repairs needed, economic productivity lost. The **UN Sendai Framework** is an initiative to reduce economic loss due to a disaster, after the huge economic losses during the 2011 Tohoku Earthquake & Tsunami.
- You could compare a tectonic disaster to **previous events**, **prediction models** or average statistics for that location. Some events may be more severe than the

‘average’ tectonic hazard, due to a series of factors coinciding (e.g. bad weather and recent deforestation will increase the tsunami travelling inland).

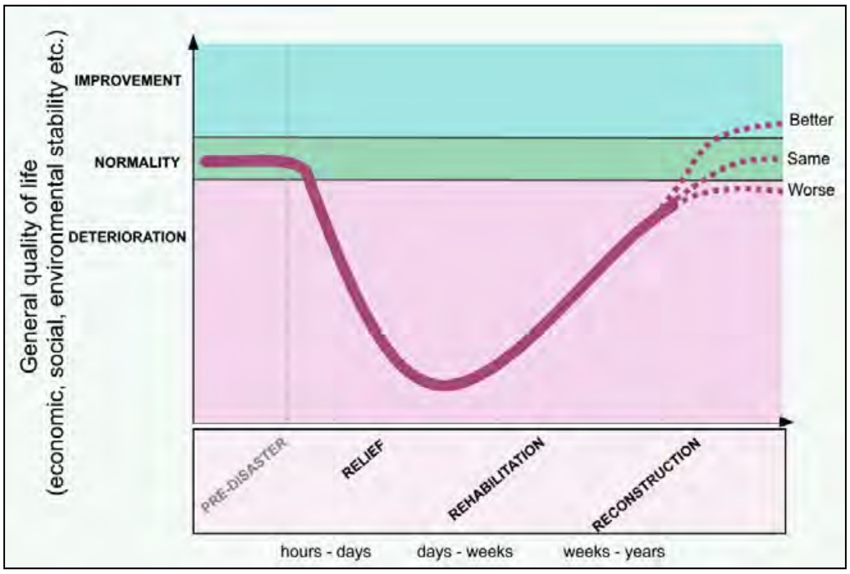
It is important to treat average statistics carefully - rare mega-disasters could skew the statistics. *For example, if you take 100 tectonic events for Iceland - 99 events cause 3 fatalities and 1 event causes 10,000 fatalities (not real data!) - would the average fatality of 103 people be* ***representative*** *of all tectonic events that occur in Iceland?*

The Park Model

The Park Model is a **graphical representation** of human responses to hazards. The model shows the steps carried out in the **recovery** after a hazard, giving a rough indication of **time frame**.

- The **steepness** of the curve shows how **quickly** an area **deteriorates** and **recovers**.
- The **depth** of the curve shows the **scale** of the **disaster** (i.e. lower the curve, lower the quality of life).

The Park Model **of Human Response to Hazards**



Stage 1 - Relief (hours-days)

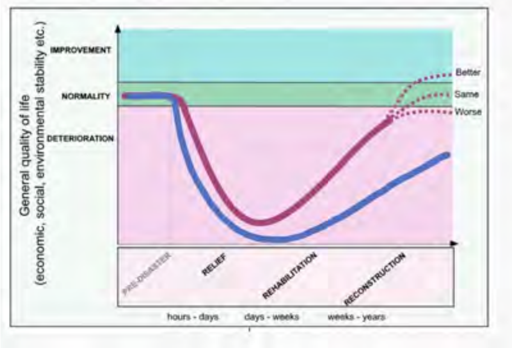
- **Immediate** local **response** - medical aid, search and rescue
- Immediate appeal for **foreign aid** - the beginnings of global response

Stage 2 - Rehabilitation (days-weeks)

- **Services** begin to be restored
- **Temporary shelters** and **hospitals** set up
- **Food and water** distributed
- **Coordinated foreign aid** - peacekeeping forces etc.

Stage 3 - Reconstruction (weeks-years)

- **Restoring** the area to the same or better quality of life
- Area back to **normal** - ecosystem restored, crops regrown
- **Infrastructure** rebuilt
- Mitigation efforts for **future event**



The model also works as a **control line** to compare hazards. An **extremely catastrophic hazard** would have a **steeper curve** than the average and would have a **slower recovery time** than the average, for example. This has been indicated by the blue line.

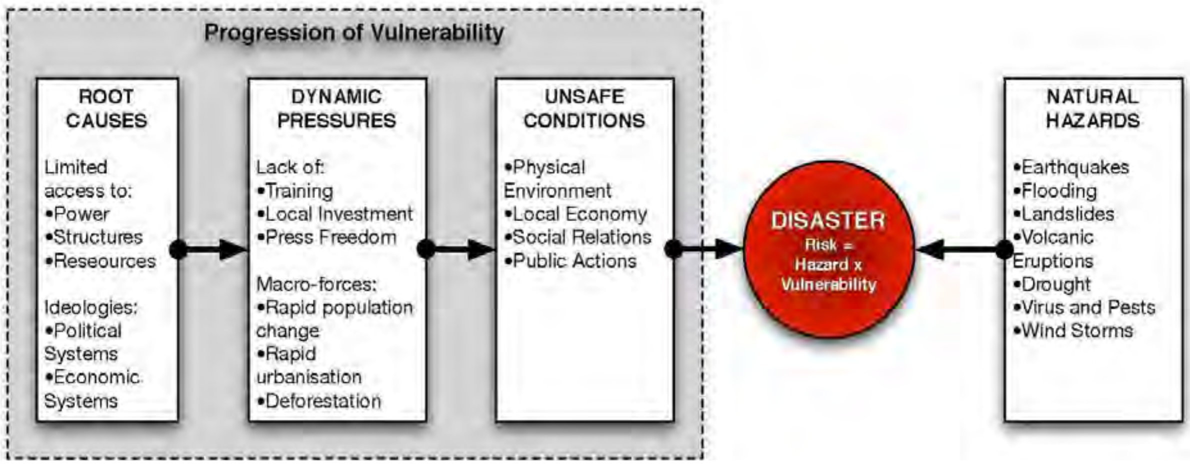
The Pressure and Release Model (PAR)

The Pressure and Release Model is used to analyse factors which cause a **population** to be vulnerable to a hazard. On one side of the model we have the **natural hazard** itself, and on the other side different factors and processes which increase a **population's vulnerability** to the hazard. This vulnerability is often rooted in **social processes**. These are dynamic and ever changing and are often unrelated to the hazard itself e.g. poverty, poor governance.

The PAR model is **complex**; no two hazards are the same and factors leading to vulnerability are **interconnected** and **hard to measure**. If we reduce the social factors affecting a population, we can reduce the **pressure** they face and so reduce their vulnerability and the effect of natural hazards.

The progression of vulnerability is split into three sections. The **root causes** are often caused by **economic, demographic and/or political processes,** often affecting large populations or entire countries. **Dynamic pressures** are local economic or political factors, that can affect a community or organisation and **unsafe conditions** are the physical conditions that affect an individual (unsafe building, low income, poor health, etc).

Therefore, the number of people affected will **increase** the closer the factor is to the root cause.



Vulnerability can be defined differently, depending on who or what is affected:

- **Physical Vulnerability** - Individuals live in a hazard-prone area, with little protection naturally or through mitigation.

- **Economic Vulnerability** - People risk losing their employment, wealth or assets during a hazard. MEDCs tend to be more economically vulnerable than LEDCs.
- **Social Vulnerability** - Communities are unable to support their disadvantaged or most vulnerable, leaving them at risk to hazards.
- **Knowledge Vulnerability** - Individuals lack training or warning to know the risks of a hazard or how to safely evacuate. Alternatively, religion and beliefs may limit their understanding of hazards; hazards are an act of God, so individuals don't mitigate or evacuate (known as fatalist belief).
- **Environmental Vulnerability** - A community's risk to a hazard is increased due to high population density in the area.

The Pressure & Release Model suggests that a series of factors leads to a population's vulnerability. For example:

A **lack of infrastructure** (such as poor sewage management or water supplies) can worsen the impacts of a hazard, since it is harder to maintain clean living conditions and avoid the spread of disease following a disaster. A lack of infrastructure would be a factor of **unsafe living conditions**.

↓

However, the lack of infrastructure may be due to **rapid urbanisation**, where little planning has been taken to carefully construct houses and infrastructure to cope with the rising population; Rapid urbanisation would be the **dynamic pressure**.

↓

Ultimately, planning and controlling safe population growth is the **government's responsibility**. So the **root cause** of this disaster may be weak governance.

Common factors that can affect the **vulnerability** of a society have been sorted below:

Root Cause:	**Dynamic Pressures:**	**Unsafe Living Conditions:**
- Weak Governance - Mismanagement by Industry, NGOs or IGOs - High reliance on products easily affected by hazards (local agriculture near to the hazard, imports by air during a volcanic eruption)	- lack of training/knowledge in locals. - rapid urbanisation - poor communication between government and locals - natural environment	- lack of infrastructure (clean water, sewage removal, electricity) - dangerous location of settlements (close to nuclear stations or the natural hazard itself) - no warning system for locals

	degraded (mangroves removed, rivers & channels filled with debris) - lack of basic services (health, education, police)	- disease and fire can easily spread between households

Tectonic Hazard Profiles

A hazard profile compares the **physical characteristics** which all hazards share. Hazard Profiles can help **decision makers** when deciding where to allocate the most human and financial resources.

It is easy to measure a single hazard like earthquakes but it is much more difficult to measure multiple hazards or events were secondary hazards are more destructive than the actual event itself.

The characteristics of a hazard profile included:

- **Frequency** – How often it happens
- **Magnitude** – How extensive an area the event could affect
- **Duration** – How long the event lasts
- **Speed of onset** – How much warning time before event occurs
- **Fatalities** - Number of deaths caused
- **Economic Loss** - Value of assets damaged, lack of industry or economic productivity, insurance policies.
- **Spatial Predictability** - The predictability of where would be affected.

Evaluating the Effectiveness of Models

Hazard models are useful, but the **unpredictability** of hazards makes the models less effective at accurately representing human responses to hazards. It may be useful to ask some questions when evaluating how effective these models are:

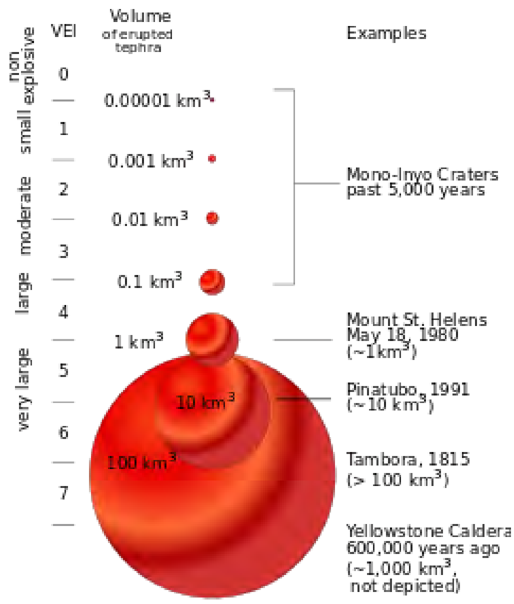
- Can they be **applied** to every hazard? Are some hazards more complicated and require a more **complex model**? It may be useful to apply each of your case studies to these models and see how they compare.
- Does the model take any **aspects of hazards** into account such as **level of development**?
- Is there any **timeframe**? Do the models accurately lay out the time taken for a full response and how this changes due to **aspects of the hazard** such as intensity?
- Could the model be **less vague**/ include more steps that can be applied to all hazards?

- Does the model present hazards **currently**? Are there any alterations that could be made to account for hazards affected by **climate change**? Will the model eventually not represent human responses at the time (e.g. could the cycle stop because hazards will occur more frequently than the mitigation strategies will occur)?

Measuring Tectonic Events

Volcanic Explosivity Index (VEI)

- Measures the **relative explosiveness** of a volcanic eruption.
- Based on the **height** of ejected material and **duration** of eruption.
- Scale goes from 0-8 and is **logarithmic** (increase of 1 on the scale indicated a 10 times more powerful eruption).



The Modified Mercalli Scale

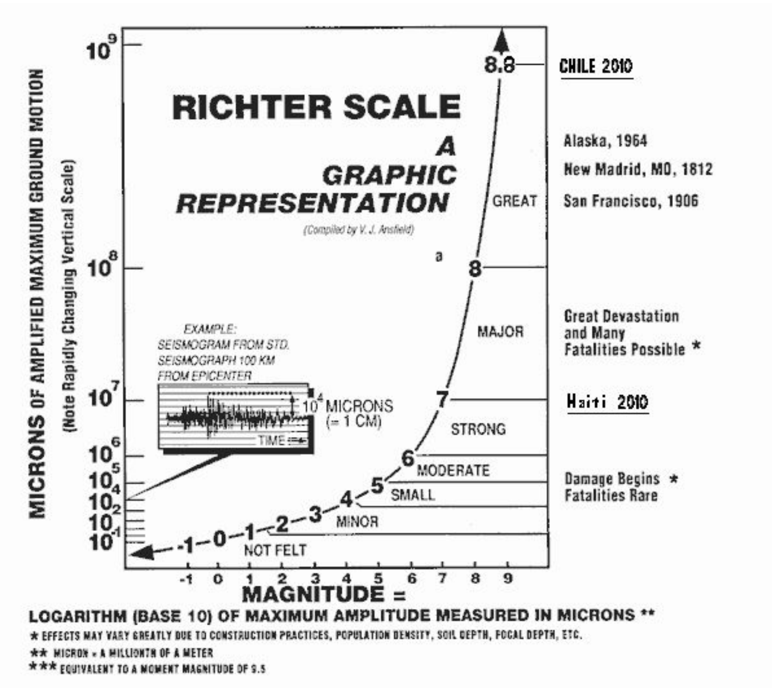
- Measures the **destructiveness** of an earthquake.
- It is a **relative** scale as people would feel different amounts of shaking in different places.
- It **subjective** as based on if people wake up, if furniture moves, how much damaged structures receive.
- The scale varies from I to XII

  I = Generally not felt by detected on seismographs
  XII = Nearly total destruction

- It doesn't consider economic, social and environmental impacts.

Moment Magnitude Scale

- Measures the amount of **energy** released in earthquake.
- Scale from 0-9.
- It's a **simple** measure, so environmental or social impacts must be inferred.

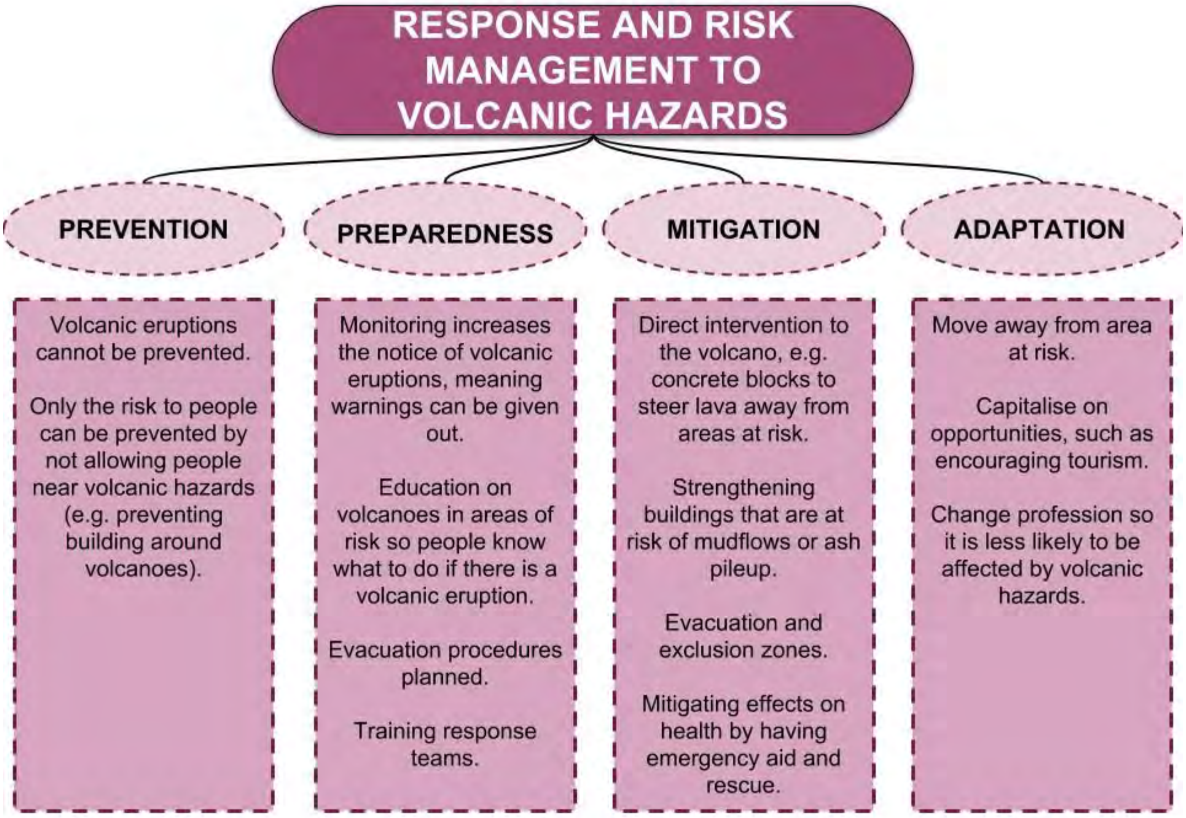


Richter Scale

- Measures the **amplitude** of the waves produces during an earthquake
- Most widely used scale, as it's **absolute**
- Must infer social or environmental impacts, which can be misleading. The highest Richter scale earthquake readings won't necessarily be the worst disasters.
- Like the VEI its scale is **logarithmic**.

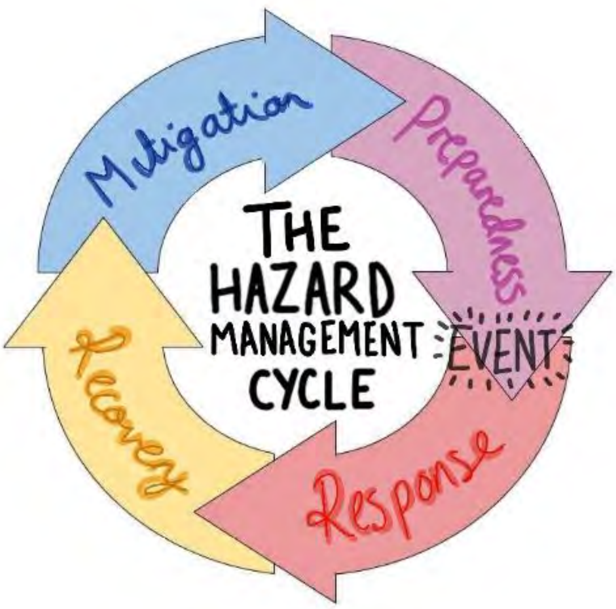
Managing Tectonic Hazards

Hazards can be responded to by **preventing** them directly, being **prepared** for the next hazard, **mitigating** the effects, or completely **adapting** your lifestyle to limit the hazard's effects.



The Hazard Management Cycle

The **Hazard Management Cycle** outlines the **stages of responding to events**, showing how the same stages take place after every hazard.



Preparedness	Response	Recovery	Mitigation
Being **ready** for an event to occur (public awareness, education, training)	**Immediate action** taken after event (evacuation, medical assistance, rescue)	**Long-term responses** (restoring services, reconstruction)	Strategies to **lessen effects of another hazard** (barriers, warning signals developed, observatories)

Monitoring and Prediction:

It is not possible for us to **predict accurately** when an earthquake will happen; instead, the risk of an earthquake can be **forecast** based on a statistical likelihood. Forecasts can be based on data and evidence gathered through **global seismic monitoring** networks and also from **historical records**.

Scientists can sometimes predict volcanic eruptions with some degree of **accuracy**. Scientists can use special equipment to monitor volcanoes and detect signs of imminent eruption:

- Small earthquakes - called **tremors**
- Changes to the **top surface** of the volcano as it swells when magma builds up
- Changes to the **tilt** as the slope angle changes when magma builds up

Mitigation: Identifies the **characteristics** of the potential hazard and what can be done **reduce their impact** on people, such as:

- Land use zoning
- Building codes and regulation
- Protective defences (tsunami wall)

Preparedness: Minimising loss of life and property

- Developing preparation plans
- Developing warning systems
- Stockpiling medicines, food, water etc.
- Education, training, drill

Response: Coping with a disaster, the main aims would be to rescue people and reduce economic losses:

- Search and rescue efforts
- Evacuating people
- Restoring vital infrastructure like water and electricity
- Restoring vital services like law enforcement and health care

Local Aid and International Aid:
Focuses on short-term and long-term recovery

Short-term:

- Providing aid, food, water, shelter
- Providing financial assistance so people can rebuild their livelihoods

Long term:
- Rebuilding homes
- Building and repairing infrastructure
- Reopening schools and businesses

Management Approaches

There are **three** different approaches to managing a tectonic hazard and reducing their impact: **Modify the Event, Modify the Vulnerability, Modify the Loss**.

Modify the Event

We cannot control seismic activity. However, we can control the **design of buildings** (said to be the biggest **killer** during a natural disaster) through civil engineering using micro and macro methods.
Micro → Strengthening individual buildings and structures
Macro → Large scale support and protective measures designed to protect whole communities

For Earthquake:
- Mainly micro approach
- Emphasis put into **public buildings** like hospitals, police stations and other vital infrastructure
- Schools and factories strengthened to help **shelter people**
- Some improvements to private houses

For Tsunamis:
- **Tsunami walls** which work for a given amplitude and threshold of wave
- Replanting coasts with **mangroves** and coastal forestry which dissipates energy from waves

For Volcanoes:
- Diverting flows of lava
- **Reinforce house roofs** to withstand large deposits of ash

Type of modification	Advantages	Disadvantages
Land use zoning Preventing building on low lying areas and areas of high risk	Low cost Reduces vulnerability	Stops economic development on some high value land Strict enforcement required
Resistant buildings Buildings with deep foundations, sloped roofs so that ash doesn't build and create pressure	Can help prevent collapsing Protects people and property	High cost for larger buildings Low income families cannot afford this
Tsunami defences Sea walls which stop waves travelling inland	Reduces damage Provides security	Very high cost Doesn't look nice Can be overtopped

Lava diversion Barriers and water cooling to divert and slow down lava flow	Diverts lava away Low cost	Only works for low VEI lava

Modify the Vulnerability

Type of modification	Advantages	Disadvantages
Hi Tech Scientific Monitoring Monitors volcano behaviour and predict eruptions	Predicting eruption is possible in some cases Warning and evacuation can help save lives	Costly, in LDCs, volcanoes aren't usually monitored Doesn't prevent property damage
Community Preparedness and Education	Low cost and often implemented by NGOs Can save lives through small actions	Doesn't prevent property damage Harder to implement in isolated rural areas
Adaptation Moving out of harm's way and relocation	Helps save lives and property	High population densities prevent it Disrupts people's traditional home and traditions

Modify the Loss

Modification + Example	Advantages	Disadvantages
Short term aid Search and rescue and also food, water, aid and shelter	Can help reduce death toll by saving lived and keeping people alive until long term aid is provided	High costs and technical difficulties in isolated areas Emergency services are limited and are poorly equipped in LDC
Long term aid Reconstructions plant to rebuild an area and improve resilience	Reconstruction can help improve resilience through land use planning and better construction methods	Very high costs Needs are quickly forgotten by the media shortly are the disaster
Insurance Compensation to replace losses	Allows people to recover economically for paying reconstruction	Doesn't help save lives Not many in LDCs have insurance

The role of communities – In remote and isolated areas, it may take a long time for aid to come and people may begin **local recovery operations**, communities may clear debris from roads and set up temporary shelters.

The role of NGOs & TNCs – NGOs play a very important role from providing funds, coordination rescue efforts and helping to develop reconstruction plans. Occasionally, TNCs and NGOs may cooperate; Charity buckets or events may be organised by businesses to improve IGOs ability to help.

Development and Governance

Governments of developing countries may not prioritise investing money in **hazard mitigation** as they tend to focus their resources on development and economic growth. This lack of investment in hazard management often means that less developed countries and their populations are more vulnerable to hazards.

The **Risk Poverty Nexus** states that poverty is both a contributing factor and consequence of a natural hazard. It also suggests that a **positive feedback mechanism** can cause further economic loss for already poor countries.

Low income households and communities are generally more affected by impacts and losses. There are various types of inequalities, each affecting a community's resilience to a hazard:

- **Asset inequality** – Relates to housing and security of tenure and also agricultural productivity.
- **Political inequality** – Where certain groups of people, usually the wealthy and elite, hold quite a lot of power and political influence.
- **Social status inequality** – Often directly linked to space and has a bearing on other dimensions of inequality, including the ability of individuals and groups to secure regular income and access services.
- **Entitlement inequality** – Refers to unequal access to public services and welfare systems as well as inequalities in the application of rule of law.

Hazard Vulnerability

There are many factors that can contribute to a population's vulnerability:

- **Unstable political governance** and/or **corruption** - a lack of political cohesion can impact on how prepared a country is for a hazard and can also negatively impact response and recovery efforts after the event.
- **Population density** - the higher the population density the more people affected by a hazard.
- Geography **isolation** and accessibility - remote, rural areas often have poor transport links which can negatively effect rescue efforts.
- Level of **urbanisation** - urban areas tend to be worse affected by hazards due to two factors: urban areas are densely populated (see above) and also have larger amounts of infrastructure meaning there is more economic damage.

Governance

- **Meeting basic needs** - When food supply, water supply and health needs are met, the population is generally less vulnerable to secondary hazards such as diseases.
- **Planning** - Land-use planning can reduce risk by preventing people living in areas of high risk. Secondary hazards may be made worse by deforestation.
- **Preparedness** - Education and community preparation programmes raise awareness and teach people how to prepare, evacuate and act when a disaster strikes.
- **Corruption** - If government politicians accept bribes and do unethical things, then vulnerability would increase as money would be invested in crucial areas like emergency services.

Tectonic Mega-Disasters

Characteristics:

- Large scale disaster affecting a **large spatial areas** or **large population.**
- They pose problems in effective management to minimise the impacts.
- The scale of the impact may require **international support and aid.**
- Mega Disasters are **low probability** (rare).

The globalisation of production and supply chains has allowed **international businesses** to reduce the costs and become more efficient. However, mega-disasters significantly damage globalised businesses.

There are many different examples of business disruption by mega-disasters:

- **2011 Tohoku earthquake & tsunami** - There was a knock on effect for TNCs such as Toyota and BMW which operate and source products from Japan. This lost potential revenue for those TNCs and caused general economic uncertainty.
- **2011 Eyjafjallajökull eruption** - The significant ash cloud closed European air space, which lead to the halt of goods and trade into the EU by air. This resulted in Kenyan flowers (to be imported into the EU) couldn't be transported and wilted.