# Theme D: The Restless Earth Cheat Sheet

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## Plate Tectonics (Theory)

The *core* of the earth is made up of dense materials (iron) & nickel, with a liquid outer core and solid inner core.

The *mantle* of the earth is the thickest layer of the earth, made up of silicate rocks which due to high temperatures (3500 degrees) remain molten and float about.

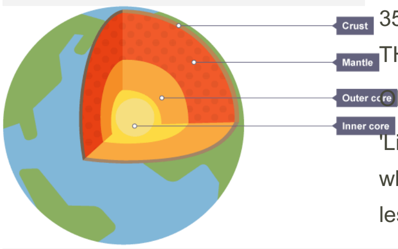
The *crust* is the thin layer. Broken into several pieces known as plates which move due to convection currents within the mantle.

**Theory of Plate Tectonics**

The surface of the earth is moving - less than 1cm a year, but over many years these small movements have a big impact. Hard crystal rock sits on a layer of molten mantle rock - these sections of crystal rock are called plates and they are moved by pressure and heat from inside the earth.

The theory of plate tectonics is credited to Alfred Wegener.

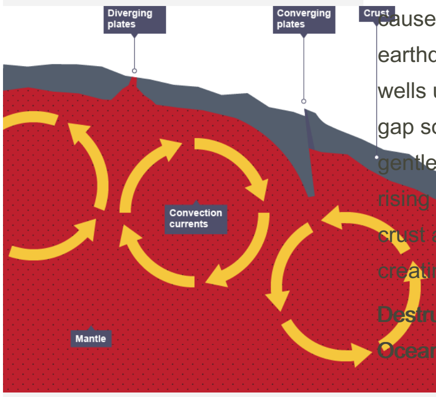
## Diagram of Earth




## Convection Currents

Convection currents are within the mantle and are heated by magma in the outer core. Due to heat it is less dense and the magma rises. After hitting the crust, the magma is forced to spread out. After heat spreads out it cools and sinks back down, this is continuous and causes movement in crust. While currents descend they drag crust into mantle (destructive margin)

## Convection Currents




## Plate Types

| Continental Plates | Oceanic Plates |
|---|---|
| 35-100km - THICK | 6-10km - THIN |
| Old rocks | Young rocks |
| 'Light' rocks which are less dense | 'Heavy' rocks which are more dense |
| Granite | Basalt |
| Hard to destroy | Easier to destroy |

## Plate Types (cont)

| | |
|---|---|
| Does not easily sink into mantle | Can sink into mantle |

## Plate Margins

**Constructive Plate Margins - Mid Ocean Ridges**

One constructive margin is found in the middle of the Atlantic ocean. Here the Eurasian and North American plates are being pulled apart, moving away from one another. This means the Atlantic ocean is getting wider apart by approx. 3cm per year. The movement causes regular but weak earthquake activity. Magma wells up from mantle to plug the gap so there is often frequent gentle volcanic activity. This rising of material pushes up crust at either side slightly, thus creating a mid-oceanic ridge.

**Destructive Plate Margins - Oceanic-Continental Crust**

## Plate Margins (cont)

An example would be found in South America. Here the Nazca plate, made of Oceanic crust, is disappearing below the American plate. At plate margin, dense oceanic crust is pushed downwards. As it is dense it falls below its normal level, creating a deep ocean trench (Peru-Chile). Movement is not smooth due to rough surface friction. Plates may become stuck for years until pressure is greater than friction. Will cause plates to jolt and move suddenly. Felt on Earth's surface as an earthquake.

**Destructive Plate Margins - Oceanic-Oceanic Crust**

Violent activity. An oceanic crust margin where oceanic crust and oceanic crust meet. Has many similar features to first type of destructive margin. As the oceanic sinks into mantle, it melts and creates a less dense material than surrounding rock. Deep ocean trench forms where dense material pushed down into mantle. Can be very deep. Magma then rises upward and may erupt through crust to create volcanic island.

**Collision - Continental-Continental Crust**

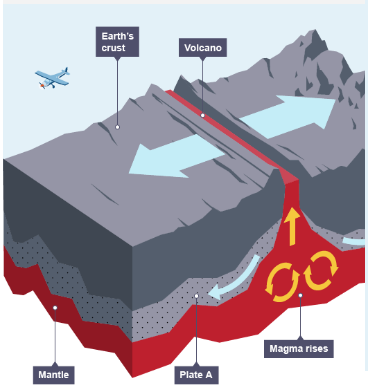
## Plate Margins (cont)

Where two continental plates meet is a collision zone. Crusts of both plates buckle and fold upwards. Two sets of fold mountains overthrust one another, creating large range of fold mountains. Little material melting and that which does not melt cannot make it through high mountains to make volcano. Instead, magma forms large intrusions into mountain range. Magma cools slowly to form granite cores to mountains.

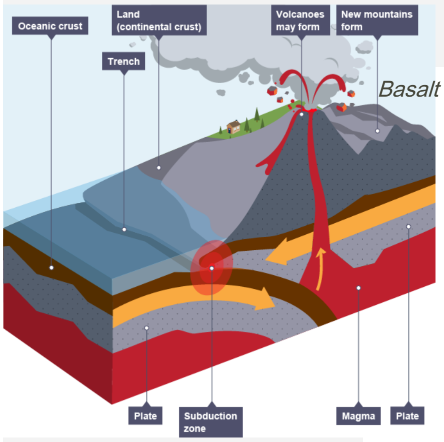
### Conservative Plate Margins - Fault Lines

Violent activity. At conservative margins, such as San Andreas fault line (California) two plates try to slide past one another. Friction causes plates to stick, pressure is built up and is eventually released as an earthquake when plates jolt suddenly. Crust is neither created or destroyed so therefore no volcanic eruptions.

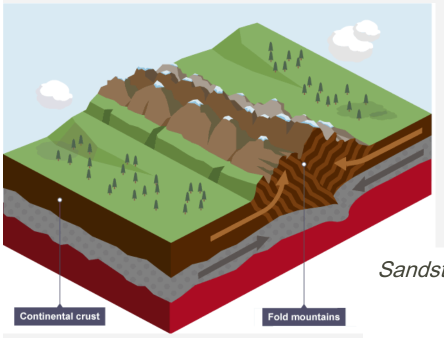
## Constructive Plate Margin




## Destructive Plate Margin




## Collision Zones




## Conservative Plate Margin


## Basic Rocks

| | Type | Characteristics | Use |
|---|---|---|---|
| *Basalt* | I | Very hard, dark grey rock. Feels rough and heavy. Small glittery specks. | Construction |
| *Granite* | I | Rough texture and speckled colour. Often pink or grey. | Worktops, gravestones, construction, decoration |
| *Sandstone* | S | Formed from grains of sand. No crystals. Feels rough and hard. | Statues, construction |
| *Limestone* | S | Grey, white or yellow. May be hard and contain fossils and layers. Porous. | Neutralises acidic soil, glass, some buildings, cement |

## Basic Rocks (cont)

| | | | |
|---|---|---|---|
| *Slate* | M | Dark grey rock with easily split layers. Smooth, flat surface. Impermeable. | Roofs |
| *Marble* | M | May be pure white or have swirls or bands of colour. Rough and grainy when unpolished. | Construction |

## Basic Rock Types

### Igneous Rocks

## Basic Rock Types (cont)

These include basalt and granite and they have been formed by cooling and solidifying of molten rock (magma) from underneath the earth's crust. This molten rock is called lava on the surface of the earth. Crystals are usually evident in the rock. However, if the rock cools quickly as the lava hardens on the surface, there will be little evidence of the crystals (basalt). If the magma is cooled slowly underground, then a cystalline structure will be more evident (granite).

### Sedimentary Rocks

Limestone and sandstone are formed by sediments being built up in layers, usually under water over a long period of time. As more and more eroded material is added, pressure pushes air and water out and the sediment gets cemented into rock.

### Metamorphic Rocks

Slate and marble have been changed through the addition of pressure or heat. The rocks would originally have been igneous or sedimentary - marble once was limestone. Metamorphic rocks are hard and resistant to erosion.

## Managing Earthquakes

## Case Study - Indian Ocean Earthquake 2004

### Spatial Context

26th December 2004. Sumatra, Indonesia (West Coast). Magnitude of 9.2, duration of 10 minutes. Australian and Sunda plates responsible.

### Causes

- Major fault line where Australian plate meets Sunda plate. Part of a subduction zone, 15m slippage along fault line in two stages causing prolonged earthquake.
- Ocean floor rose by several metres, causing a large tsunami.

### Short Term Impacts - People

- 66% of Sri Lanka fishing fleet destroyed which had economic implications due to fishing being direct employment for a quarter of a million.
- 125,000+ injured
- 1.1mil temporarily displaced due to coastal devastation

### Long Term Impacts - People

- Death toll just under 187,000 - a third of which being children
- In Maldives, 17 coral attol islands had freshwater supply contaminated. Inhabitable for decades.
- Widespread mental trauma due to being unable to uphold Islamic belief of having to bury deceased.

## Case Study - Indian Ocean Earthquake 2004 (cont)

- Rebel group ceased fire against government.

### Short Term Impacts - Environment

- 30m high tsunami; countries affected on all sides of Indian ocean
- Whole earth vibrated by 1cm due to energy released, 1502 times that of atomic bomb on Hiroshima.
- Aftershocks continued for 3 to 4 months afterwards

### Long Term Impacts - Environment

- Raising of seabed reduced Indian ocean capacity and raised global sea level by 0.1mm
- Coastal ecosystems of affected areas severely damaged; mangroves and coral reefs destroyed.
- Massive release of energy expected to shorten length of day by 2.68 micro seconds; change to earth's shape.

### Management Response

- Area affected used to minor quakes and volcanic eruptions but made up of poor LEDCs and lack resources to have scale and quality of response that MEDCs have.

### Before the Earthquake; Prediction and Precaution

- No early warning system to record underground quakes. Simeulue island evacuated coastal areas as tremors were felt; fled to inland hills.

## Case Study - Indian Ocean Earthquake 2004 (cont)

- Tilly Smith Phucket recognised warning signs and helped evacuate beach.

### Immediate and Longterm Action After Earthquake

- World pulled together to provide aid. Over £7 billion donated from national government and non-government operations.
- Sri Lanka, Indonesia and Maldives declared state of emergency. Strict laws implemented to keep order.
- Review of poor earthquake and tsunami warning system around Indian ocean took place and in June 2006, 25 new seismograph stations relaying information to national tsunami centres became operational.

### How prepared is Indonesia for a similar earthquake today?

- City of Banda Aceh rebuilt by 2014.
- Park and memorial site built around 2,600 ton ship that washed up on shore.
- Population back to 250,000 (almost the same as 2004).
- New highways and vibrant night life.
- Banda Aceh has 3/4 evacuation centres with open ground floors to allow tsunami waters to pass through.

## Case Study - Indian Ocean Earthquake 2004 (cont)

- Country's location on border of a number of dangerous fault lines between tectonic plates means another large earthquake is inevitable. One of the most notable is Sunda, megathrust fault line, parallel to Sumarta and Java Islands. Even an instantaneous alert would not give residents enough time to reach high ground (30 minutes)

## The Global Distribution of Earthquakes

An earthquake is described as a "fault rapture that generates seismic waves".

This occurs when rocks on either side of a weakness in the earth's crust (fault) causes the ground to vibrate and shake.

When a movement takes place deep within the earth, the vibrations (seismic waves) travel from the *focus* (where the earthquake originally occurs) and from here to the surface. *Epicentre* is the place on the earth's surface which is above the focus - this is where the intensity or the magnitude of energy released is felt the most.

## The Global Distribution of Earthquakes (cont)

*Seismic waves* are recorded by a seismograph. During an earthquake the base of the seismometer will move horizontally and the motion is converted into electrical voltage and recorded on paper.

The strength of an earthquake is referred to as its magnitude and in 1935 Charles Richter developed his logarithmic scale - an earthquake of 6 will be ten times greater than a strength 5.

## After Effects of Earthquakes

### Liquefaction

Liquefaction occurs when an earthquake hits an area and shakes the wet soil. The shaking causes the water within the soil to start and rise up to the surface, and this process turns solid soil and rock into a liquid mud. Buildings will start to sink and tip over as the support for the foundations is waterlogged and cannot maintain the weight of the buildings.

### Tsunami

A tsunami is a large wave which is created when an underwater earthquake sends shockwaves through the water, causing a surge of water to move towards the coastline. The energy can travel for thousands of miles across the ocean.

## Volcanoes: Characteristics & Consequences

A *volcano* is a cone shaped mountain built up from hardened ash and lava from molten materials which can erupt onto the earth's surface.

During an eruption a volcano may eject ash, hard bits of rock (volcanic bombs), lava or gasses.

### Composite Volcanoes

(Formation) Found at destructive plate margins.

Composite volcanoes have very steep sides and a narrow base.

Lava builds up in a magma chamber underneath the volcano. This can be added to as more oceanic crust melts at the plate margin.

The lava is very thick (acid) and so clogs up the main vent of the volcano, causing a "plug effect".

The pressure build-up causes an explosion which blows out ash, gas and lava.

The neck of the volcano is then cleared which allows the lava to flow out of the crater.

The layers of lava become the sides.

Alternate layers of ash and lava (ash is 1st in on eruption)

Very violent eruptions (volcanic bombs)

Slow, thick lava.

## Volcanoes: Characteristics & Consequences (cont)

Narrow base due to slow moving lava.

### Shield Volcanoes

These are found on constructive plate margins.

They also occur at hot spots under the earth's surface (not on plate boundaries, but forming a chain of volcanic islands eg. Mauna Loa, Hawaii, Usa.)

Shield volcanoes have gently sloping sides and are much wider than composite volcanoes.

They erupt frequently; gentle eruptions.

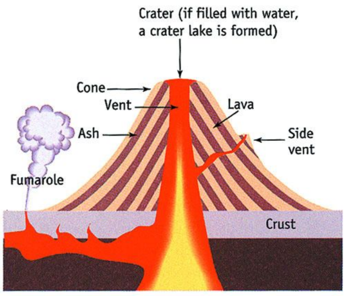
The lava is very fast and runny - basic lava (basalt), with little ash. This spreads easily and cools to form the gentle sides.

They usually occur on constructive margins where the sea floor is spreading at a mid-ocean trench.

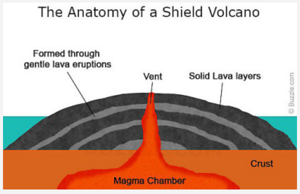
### Supervolcanoes

Classified as at least 1000km cubed of material erupted during explosion. Create wild depressions - Calderas with high ridge of land. Caldera forms when a volcano erupts so violently it collapses in on itself. Magma and pressure build up overtime, ending in a violent disruption which can disrupt the world.

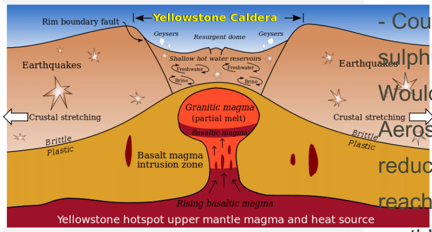
## Composite Diagram




## Shield Diagram




## Super Volcano Diagram




## Case Study - Yellowstone National Park, USA

Located in Wyoming, North West of USA.

**Background Information**

A supervolcano is classified when at least 1,000km cubed of material is erupted during the explosion. The world's first national park, Yellowstone National Park, has over 4 million visitors a year and sits on top of a supervolcano with a chamber 80km long and 20km wide.

**Potential Impacts - People**

## Case Study - Yellowstone National Park, USA (cont)

- Greatest impact in USA, almost everyone killed within 1000km blast.
- 90,000 may die from inhaling ash (cement like in human lungs). Even east coast immobilised by just 1cm ash.
- Many buildings destroyed as only takes 30cm dry ash to cause roof to collapse.
- Water supplies undrinkable.
- Transport in USA severely disrupted
- Air travel disruptions. Badly affected causing major disruption in other countries and to business.

**Potential Impacts - Environment**

- Could inject 2000mil tonnes of sulphur into earth's atmosphere. Would cloak globe in 2-3 weeks. Aerosols reflect sunlight, reducing amount of energy reaching lower atmosphere and earth's surface, cooling them.
- Global annual temperature would drop by up to 10 degrees. Could last from 6 to 10 years.
- Crop failures and 'little' ice age.
- 67 species of mammals would die causing a disrupted ecosystem for decades.
- It would take 10 years before any vegetation becomes re-established.

## Case Study - Yellowstone National Park, USA (cont)

- Acid/polluted rain infiltrating water systems killing fish.