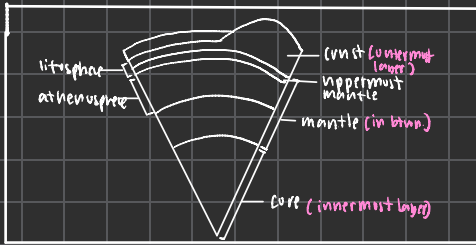


Plate tectonic theory

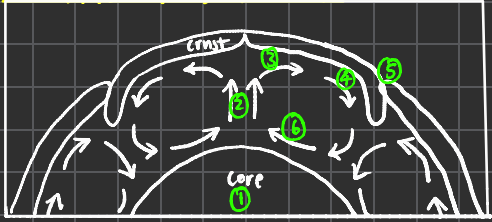
Plate Tectonic Theory explains that:

- o Earth has a three-layered structure
- o The Earth's lithosphere is broken up into huge pieces called tectonic plates
- o Tectonic plates are constantly moving
- o Plate movements result in formation of landforms (eg. mountain ranges, oceanic trenches) and phenomena (eg. earthquakes and tsunamis)



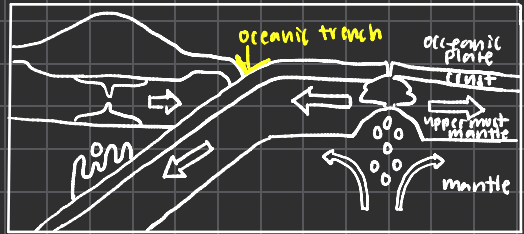
- uppermost part of the mantle and the crust are solid parts of the Earth (lithosphere)
- The lithosphere is divided into huge pieces called tectonic / plates
- 2 types of crust
 - continental (make up land mass)
 - oceanic (make up seafloor)
- Plate movements give rise to 3 types of plate boundaries
 1. divergent (moving away e.o.)
 2. convergent (moving towards e.o.)
 3. transform (sliding past)
- 2 forces responsible for plate movement:
 - convection currents
 - slab-pull force

Convection currents



- ① Heat from the earth's core causes the mantle material to become less dense
- ② mantle material rises towards the surface
- ③ The rising mantle material then spreads beneath the plates and drag them apart, causing divergent plate movement
- ④ The mantle material then loses heat and sinks towards the core
- ⑤ Convergent plate movement occurs when the convection currents collide

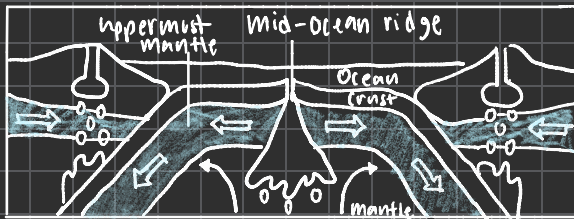
Slab-pull force



1. when two plates converge, the denser oceanic crust is pulled down by gravity as it subducts beneath the less dense crust
2. The denser oceanic crust sinks deeper into the mantle under its own weight, pulling the rest of the plate with it, contributing to further convergence

Seafloor spreading

- Q: If new seafloor is constantly being created yet the Earth does not get bigger, where does the old seafloor go?
- The old seafloor is subducted into the mantle at oceanic trenches (slab-pull force) where it melts & is recycled back into the Earth's interior



1. Where two plates move away from each other at divergent plate boundaries, seafloor spreading occurs
2. Magma from deep within the earth rises through the mid-ocean ridge
3. New oceanic crust is formed

evidence of seafloor spreading

- The age of rocks at the seafloor shows a pattern:
 - o Rocks further away from the ridge are progressively older
 - o Rocks nearer to the crest (centre) of the mid-ocean ridge are the youngest
- Shows how new oceanic crust is created at divergent boundaries and then moves laterally on both sides of the mid-ocean ridge as seafloor spreading occurs
- Little sediment accumulation is found at oceanic trenches, as older oceanic crust is being destroyed at oceanic trenches
- As a result, oceanic crusts are usually younger than continental crusts
- Proves that new crust is continually being formed at divergent boundaries at the mid-ocean ridges, and as plates move, older crust is destroyed further away at oceanic trenches

Oceanic Plate

VS

Continental Plate

- made of dense basaltic rock (rich in iron and magnesium)
- thinner (5-10 km thick)
- denser ($\sim 3.0 \text{ g/cm}^3$)
- younger — constantly forms at mid-ocean ridges and is recycled at subduction zones

- made of less dense granitic rock (rich in silica + aluminium)
- thicker (30-70 km thick)
- less dense ($\sim 2.7 \text{ g/cm}^3$)
- much older — does not get recycled as often

Trench

VS

mid-ocean ridge

- formed at convergent boundaries where one tectonic plate subducts under another
- when oceanic and continental plates converge
- boundaries where plates are being destroyed

- formed at divergent boundaries where two plates move apart, allowing magma from deep within the earth to rise through the mid-oceanic ridge
- when oceanic plates diverge
- boundaries where plates are being created

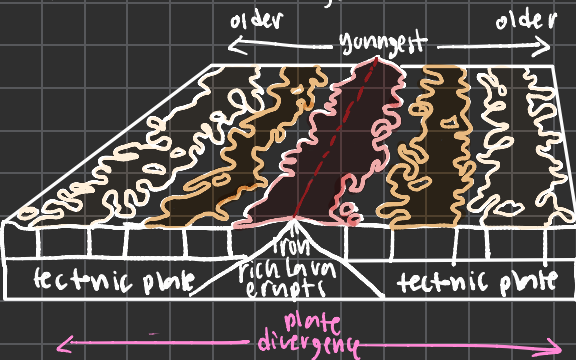
magnetic striping

Earth

- has a geographic North & geographic South, which do not change
- has a magnetic North and magnetic south that can alternate between normal polarity & reverse polarity when Earth's magnetic north points towards its geographic North and magnetic south points towards geographic South
- Over geological time, the Earth's polarity has flipped multiple times why? → (movement of liquid) in the magnetic core generates electric currents ↓ affected by temperature & drift & eventually reverse causes magnetic poles ←

what is magnetic striping?

- the zebra-like pattern where there are strips of normal polarity rocks alternating alongside strips of reversed polarity rocks on the seafloor
- it is symmetrical on both sides of the mid-ocean ridge



how does it occur?

- basaltic rocks from the oceanic crust are volcanic rocks formed from the iron-rich lava that contain magnetic minerals
- when the iron rich lava erupts, it cools and solidifies
- As it solidifies, its magnetic materials point towards Earth's magnetic North, recording evidence of the Earth's polarity at that time

how does it support plate tectonic theory?

- Zebra-like pattern is symmetrical on both sides, showing this is not a random isolated occurrence
- provides evidence that plates move as:
 1. oceanic plates diverge
 2. iron-rich lava erupts from the centre of the ridge
 3. lava cools, solidifies and forms new oceanic crust *iron minerals inside align with Earth's magnetic field
 4. As it solidifies, its magnetic materials point towards Earth's magnetic North. when Earth's polarity reverses, the rocks record the reversals
 5. As more lava moves away from the ridge due to plate divergence over time, a symmetrical zebra-like pattern forms, supporting the theory of seafloor spreading and plate tectonic theory *see call

- 1. Earth has a
- 2. lithosphere is broken up into
- 3. large rigid structures called tectonic plates that are constantly moving

Tectonic plate boundaries

- Tectonic plates (oceanic and continental) at different plate boundaries are associated with plate movements that are:
 1. Divergent,
 2. Convergent, or
 3. Transform

Divergent plate boundaries

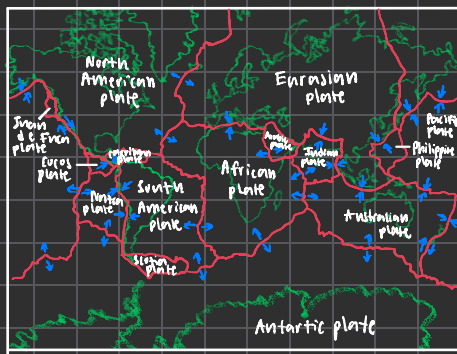
- two tectonic plates moving apart
- eg. oceanic-oceanic divergent plate boundary between North American plate and the Eurasian plate
- continental-continental divergent plate boundary between the Arabian plate and Somali plate

Convergent plate boundaries

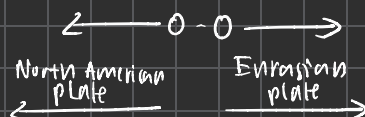
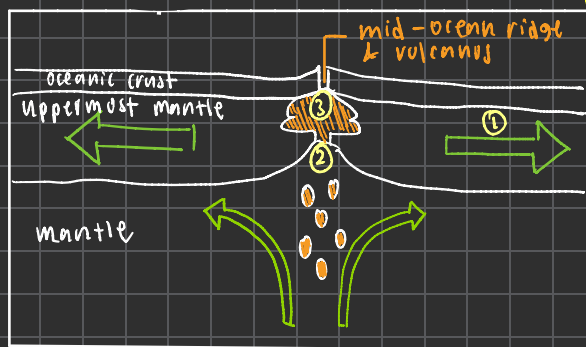
- two tectonic plates move towards each other
- eg. O-O convergent plate boundary between the Philippine plate and the Pacific plate
- C-C convergent plate boundary between the Eurasian plate & Indian plate
- C-C convergent plate boundary between the Nazca plate and the South American plate

Transform plate boundaries

- two tectonic plates slide past each other
- eg. San Andrea Fault where the Pacific plate slides past the North American plate



Oceanic-oceanic divergent plate boundaries



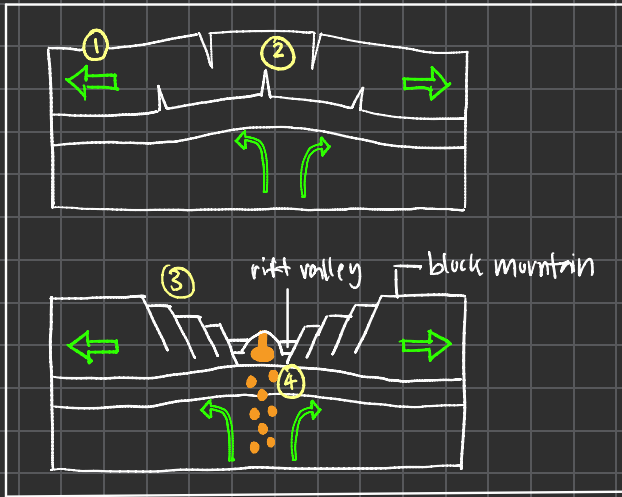
- ① mid-ocean ridge
- mid-Atlantic ridge
- ② volcanoes
- Surtsey Island (Volcanic island)
- ③ Rift valleys
→ Thingvellir rift valley (Iceland)
- ④ Earthquakes

- ① two oceanic plates move apart
 - ② the decrease in overlying pressure causes parts of the underlying mantle to melt, forming magma
 - ③ magma rises through weak areas in the crust to Earth's surface, and fills gaps caused by the spreading plates
- lava cools and solidifies to form basaltic rocks
 - these rocks make up a new oceanic crust
 - an extensive underwater mountain chain — the mid-ocean ridge — forms.
 - At the centre of the ridge is a deep valley with steep sides
 - Magma rises through the weak areas in the crust to Earth's surface, forming submarine volcanoes
 - After many eruptions, the volcanoes may break the surface of the ocean to form volcanic islands
 - Earthquakes also occur here due to stress and tension released when plates move

eg. the oceanic North American plate and the oceanic Eurasian plate diverge, forming the mid-Atlantic ridge.

→ Surtsey Island, formed in a volcanic eruption which began 130 meters below sea level

Continental-continental divergent plate boundaries



← C - C →
Nubian plate somalian plate
← →

- ① Rift valleys, block mountains
- Great Rift Valley (East Africa)
- ② Volcanoes
- Mount Kilimanjaro, Mount Kenya
- ③ Earthquakes

- ① Convection currents cause two continental plates to diverge
 - ② Rocks eventually fracture to form parallel faults due to tension
 - ③ Rock masses between these faults collapse/sink to form a deep rift valley with steep sides
 - ④ As the plates diverge, decrease in overlying pressure causes parts of the underlying mantle to melt, forming magma. Magma rises through weak areas in the crust to the Earth's surface, forming volcanoes
- Earthquakes occur as stress and tension are released when plates move

rift valley: lowland/depression in the land with steep sides along fault lines

block mountain: highland with steep sides formed along fault lines

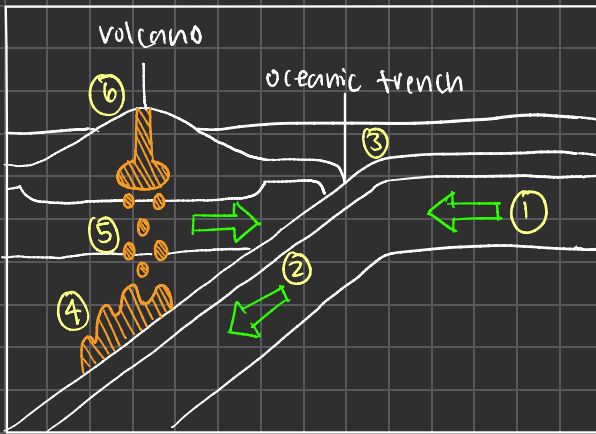
faults (lines of weakness)
→ occurs where rocks are shifted
→ process: faulting

→ due to tensional forces along fault lines

eg. Nubian plate diverges from Somalian Plate from the Great Rift Valley (East Africa)

eg. Mount Kenya, Mount Kilimanjaro

Oceanic-oceanic convergent plate boundaries



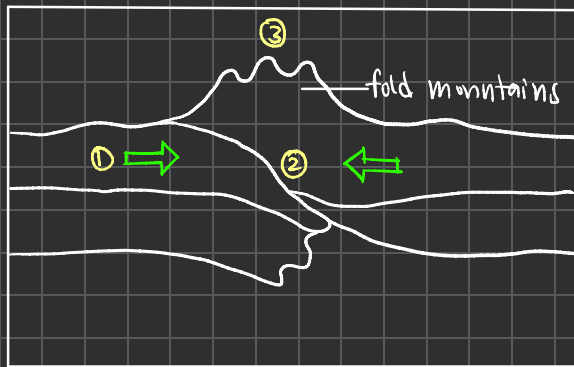
- oceanic Philippine plate → ← oceanic (Pacific plate) *denser / subducts*
- ① Oceanic trench
- Mariana trench
 - ② Volcanic islands
- Marian Islands eg. Guam
 - ③ Earthquakes
- frequently occurs at Guam

- ① two oceanic plates converge
 - ② the denser oceanic plate subducts beneath the other plate,
 - ③ forming a deep depression in the ocean floor known as an oceanic trench
 - ④ As the subducting plate sinks into the mantle, the high pressure forces water out of the oceanic plate. The water mixes with the overlying mantle, causing it to melt, forming magma
 - ⑤ Magma rises through the weak areas in the crust to Earth's surface to emerge as volcanoes
 - ⑥ Eventually a chain of volcanoes is formed, known as a volcanic islands
- Friction along the subducting oceanic plate also causes earthquakes to occur

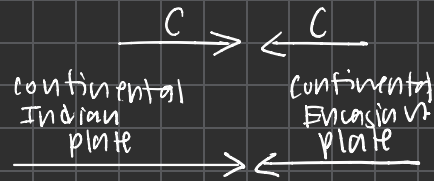
the oceanic Pacific plate subducts beneath the oceanic Philippine plate, forming the Mariana Trench and volcanic Islands known as the Marian Islands

Guam, an island near the Mariana Trench, commonly experiences earthquakes

Continental - continental convergent plate boundaries



- ① Two continental plates converge
 - ② subduction does not take place as continental plates are too buoyant to subduct
 - ③ enormous pressure causes rocks to be uplifted and buckled to form fold mountains
- friction along the convergent plate boundary also causes earthquakes to occur
- magma does not rise to the surface, ∴ no volcanoes are formed



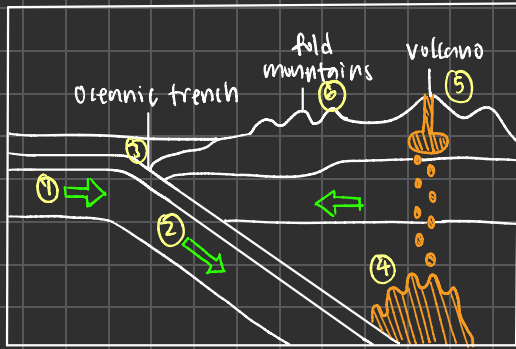
- ① fold mountains
 - Himalayan mountain range
- ② earthquakes
 - 2015 Nepal earthquake

continental Indo-Australian plate converged with the
→ continental Eurasian plate,
forming the Himalayan mountain range

Process: folding, where compressional force causes the layers of rocks to buckle and fold

→ Himalayan mountain range experiences many earthquakes (eg. 2015 Nepal earthquake)

Oceanic-continental convergent plate boundaries



oceanic
North plate → ← continental
South American plate

① Oceanic trench

— Peru-Chile trench

② Volcanoes

— Nevado del Ruiz

③ Fold mountains

— Andes fold mountain range

④ Earthquakes

— 2010 Chile earthquake

eg- Oceanic North plate

converges with the continental
South American plate. Denser
North plate subducts beneath
the South American plate, forming:

] Peru-Chile trench

] Nevado del Ruiz
volcano

] 2010 Chile earthquake

] Andes fold mountain
range

① Oceanic plate converges with continental plate

② The denser oceanic plate subducts beneath the
continental plate,

③ forming an oceanic trench in the subduction
zone

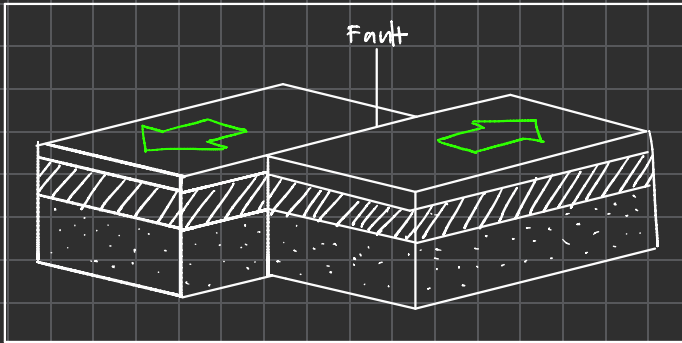
④ As the subducting oceanic plate sinks into the
mantle, the high pressure fries water out of its
oceanic crust. Water lowers the melting point
of the overlying mantle, causing it to melt,
forming magma

⑤ Magma rises through weak areas in the crust
to the Earth's surface, forming volcanoes on
the continental plate

→ Friction along the subducting oceanic plate
causes earthquakes to occur

⑥ Enormous pressure at the plate boundary
causes rocks on the continental plate to
be uplifted and buckled, forming fold
mountains

Transform plate boundary



- two plates slide past each other
- stress caused by the plate movement produces a fault, a zone of fractures
- earthquakes occur here as one plate suddenly slips past another
- magma does not rise to Earth's surface, hence there are no volcanoes

Pacific plate ↙ ↗ North American plate

① Faults

- San Andreas Fault in California

② Earthquakes

- 1989 Loma Prieta earthquake in California, USA

eg. Pacific plate sliding past the North American plate forms the San Andreas Fault in California, USA. Earthquakes are common here (eg. 1989 Loma Prieta earthquake in California)

