

Grade 10

Term 2 : Geomorphology

Key Terms:

- **Geomorphology** – study of the earth's physical features & the processes that formed them.
- **Crust** – Solid outer layers of Earth, 5-7km thick
- **Mantle** – layer between the crust and the core composed of soft rocks.
- **Core** – made of inner and outer core, total radius 8000 km, average temp 5000 degrees Celsius

Unit 1: The structure of the Earth

1. The internal structure of Earth:

➤ The crust :

- a thin layer of solid rock between 5-70km thick.
- The crust is thickest beneath the continents & thinner beneath the oceans
- The crust is the least dense layer

➤ The mantle :

- About 2900km thick.
- Rocks are in hot molten state, known as magma
- This magma is able to move and flow slowly.
- The mantle is denser than the crust

➤ **The core:**

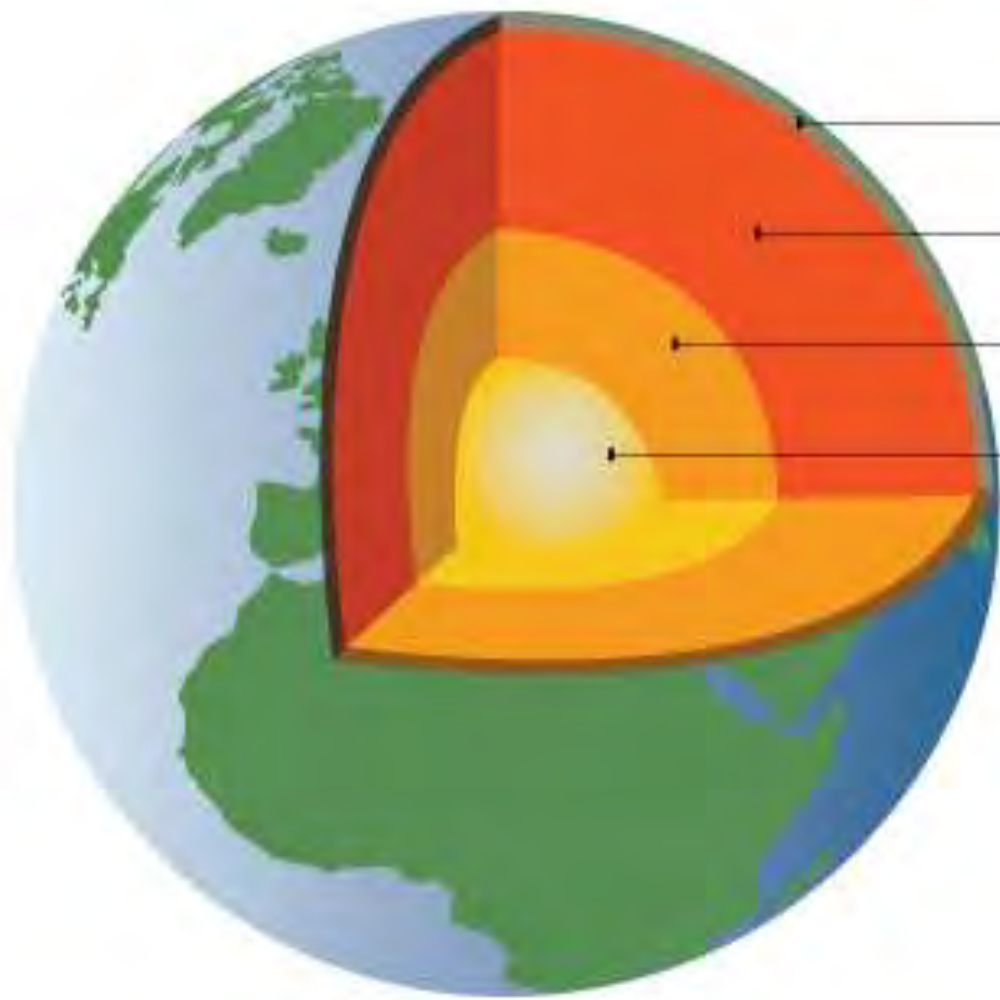
- The core is divided into the inner and outer core

1. The Outer core:

- About 2000 km thick
- Molten rock

2. The Inner core

- 1200 km thick
- Very dense
- Solid rock

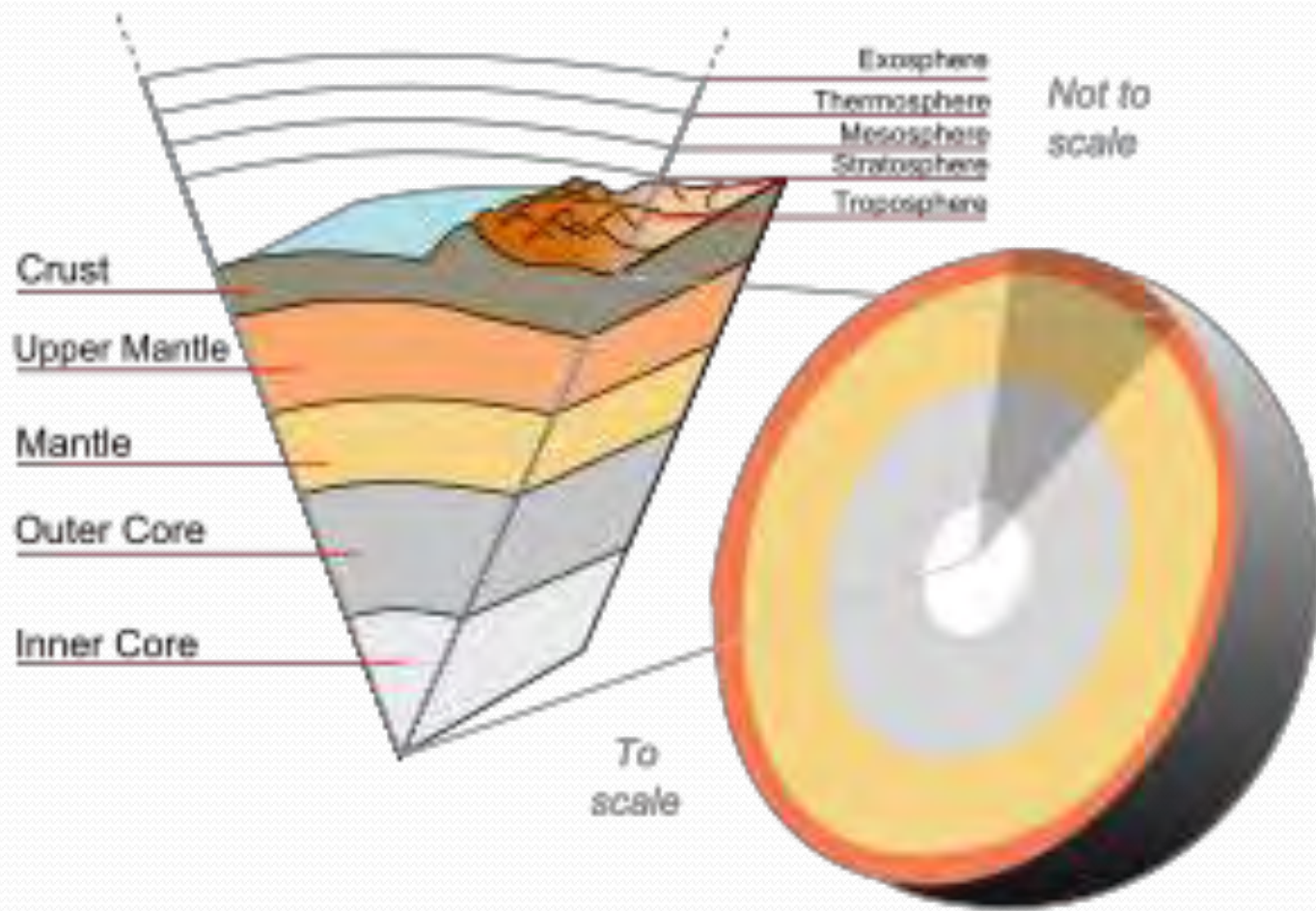


Crust

Mantle

Outer Core

Inner Core





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Unit 2: Classification of rocks

Geologists divide rocks into 3 main categories:

1. Igneous rocks
2. Sedimentary rocks
3. Metamorphic rocks

1. Igneous rocks (fire rock)

- Igneous rocks are formed from molten magma that reaches the earth's surface from a volcano and cools down to form an igneous rock.
- There are 2 types of igneous rocks:
 1. Extrusive igneous rocks (form on the earth's surface)
 2. Intrusive igneous rocks (form below the earth's surface)
- Examples of Extrusive and Intrusive igneous rocks:
 - Extrusive – basalt (found on the surface from erupted volcanoes).
 - Intrusive – Granite (found inside the earth's crust)

Extrusive Igneous Rock

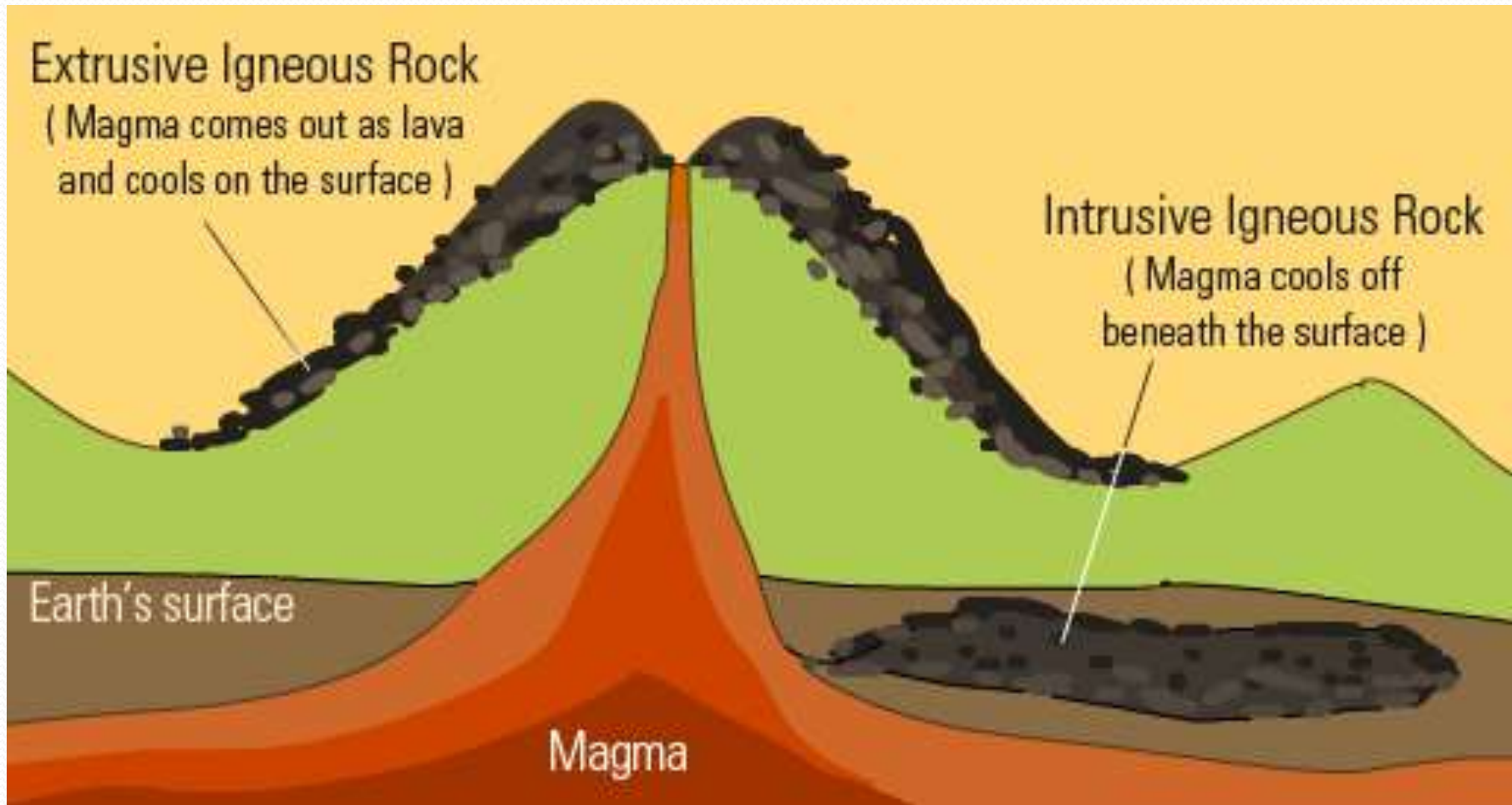
(Magma comes out as lava
and cools on the surface)

Intrusive Igneous Rock

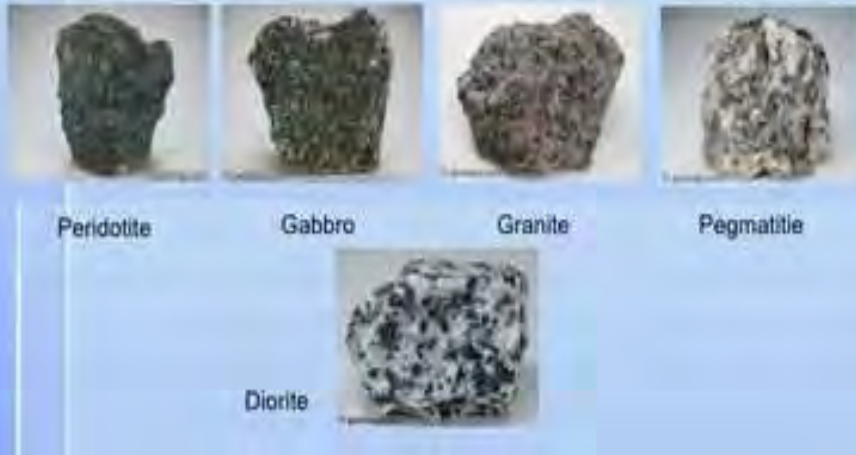
(Magma cools off
beneath the surface)

Earth's surface

Magma



- Intrusive igneous rocks
- Formed when magma "inside" the volcano cools s-l-o-w-l-y
- Forms large grain crystals



- Extrusive igneous rocks
- Formed from lava "exiting" the volcano and cooling quickly
- Forms fine-grain crystals



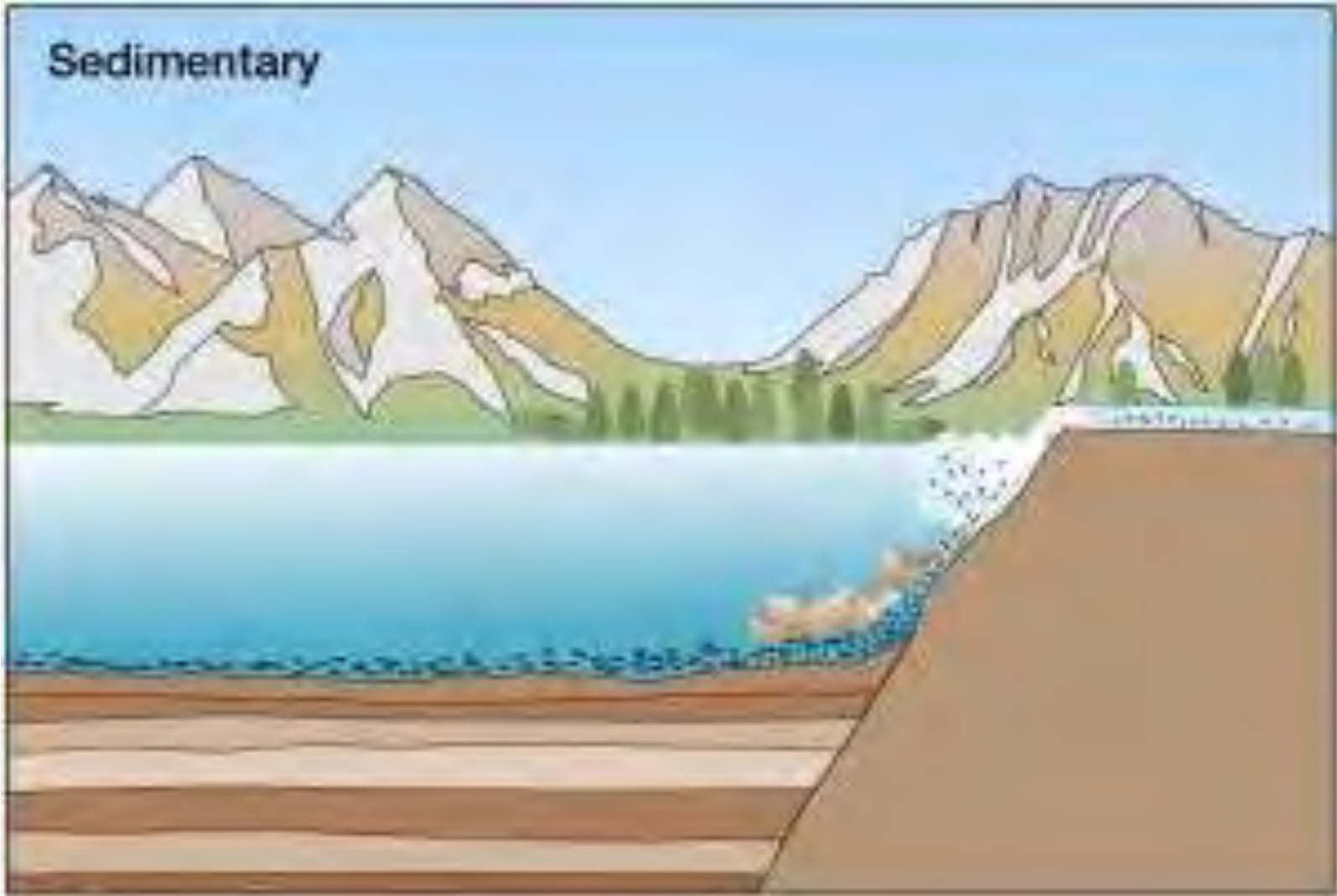
2. Sedimentary rocks

- Sedimentary rocks form from sediments that are deposited in water, usually on the floor of the ocean.
- Sediments are pieces of rock, stones, remains of plant & animals, sand and mud worn away from weathering.
- **Examples of sedimentary rocks are:**
 1. Sandstone
 2. Limestone
 3. Coal
- **There are 3 types of sedimentary rocks:**
 1. Clastic
 2. Organic
 3. Chemical & biochemical

1. Clastic sedimentary rocks

- Weathering causes rock to breakdown into smaller pieces which is carried away water, ice or wind.
- This movement of smaller rock particles causes further erosion of the earths surface.
- The forces of erosion help to produce more smaller stones, sand, soil and mud, which is called sediment.
- This sediment is deposited on ocean floors, and years of build up of layers of sediment causes the rock to form.
- Clastic sedimentary rocks are formed from small pieces of rock, sand or mud.
- Examples:
 1. Sandstone

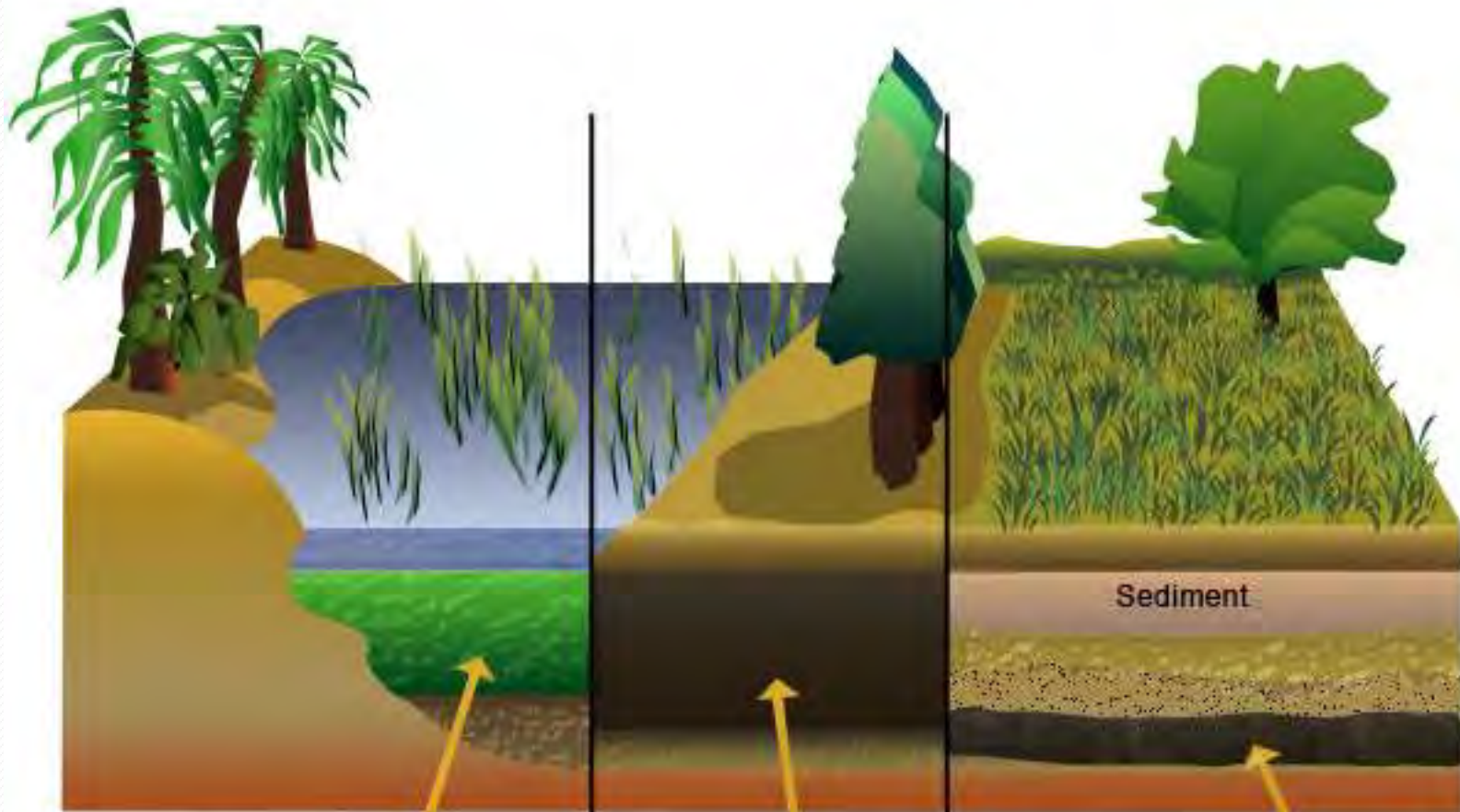
Sedimentary





2. Organic sedimentary rock

- Organic sedimentary rocks are formed from plant and animal matter.
- Coal is an example of an organic sedimentary rock
- **How coal is formed:**
 - Coal forms in swampy areas, due to the decay of plants
 - In swamps where coal is formed, other sediments such as sand, clay and silt are also deposited onto of the decaying plants.
 - The weight of the sediment compress the decaying matter, turning it into a rich dark soft substance.
 - Further compression gradually squeezes out water and causes peat to turn into rock (coal)



1. Peat (decaying plants)

2. Layers on top of the peat press down on the peat.

3. After many years of pressure and heat, the peat turns into coal.

3. Chemical & biochemical sedimentary rock

- Some sedimentary rocks are formed from chemical actions.
- Chemicals may be in solution of water, as the water evaporates the chemicals are deposited and form rocks.

Example – Rock salt



- Other chemically formed rocks come from the remains of shells from sea creatures, this type of rock is called a biochemical sedimentary rock.
- Old shells are rich in calcium carbonate, this dissolves in seawater.
- As the layers of sediment thicken the weight squeezes out the water.
- This leaves the calcium carbonate as a kind of glue, which cements other broken rock and partly dissolved shells together to form rocks.
- **EXAMPLE – LIMESTONE.**



4. Metamorphic rocks

- Metamorphic rocks were once igneous or sedimentary rocks, they have been changed by either heat or pressure.
- Contact metamorphism – process that causes rocks to change when they come into contact with magma or lava.

Metamorphic rocks formed from heat

- Rocks next to igneous intrusions below the Earth's surface are 'baked' as they are so close to the heat.
- This heat causes contact metamorphism which causes the minerals of the original rock to change to form new ones.
- Contact metamorphism can happen underground or on land if lava come into contact with rock.

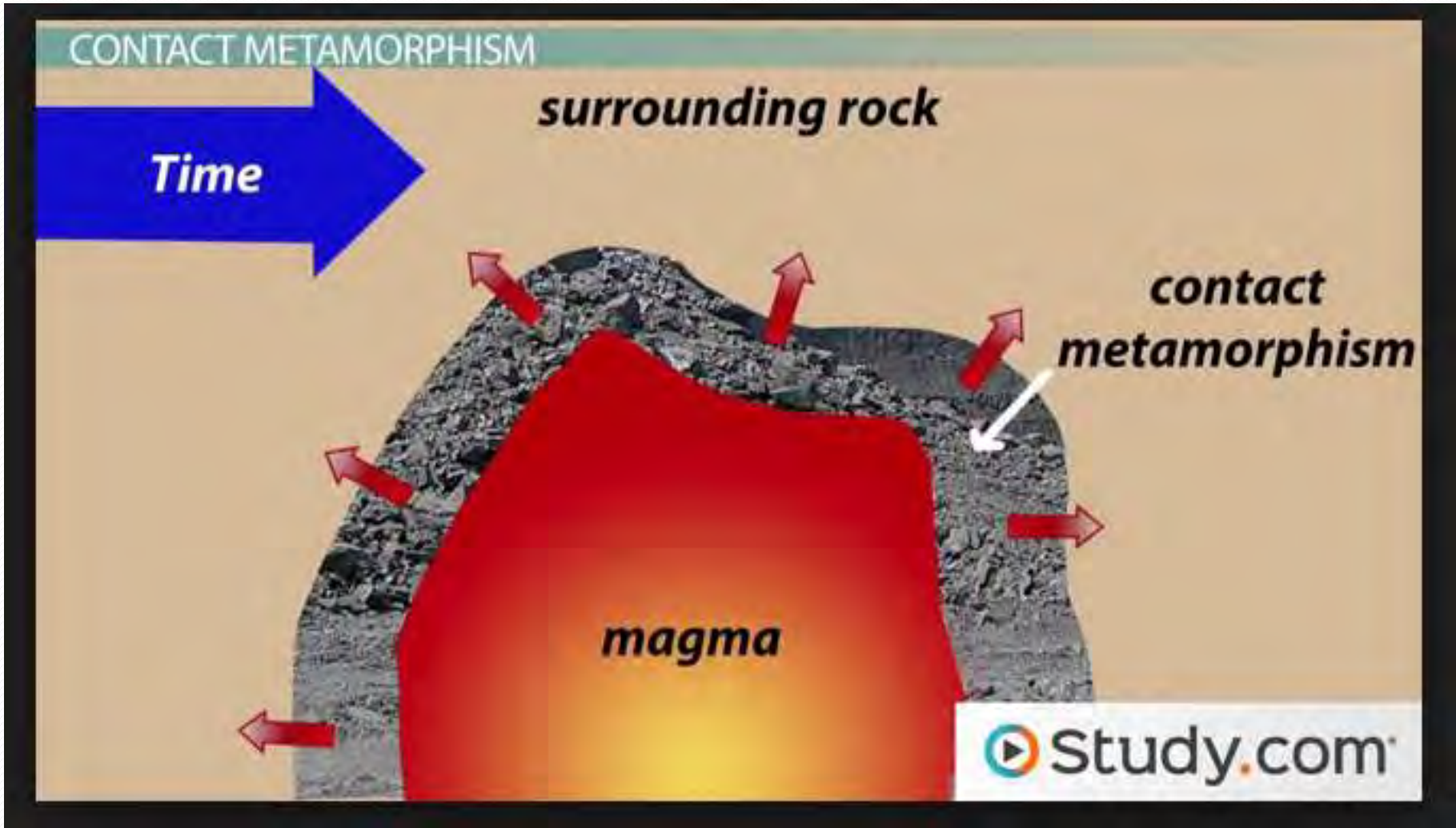
CONTACT METAMORPHISM

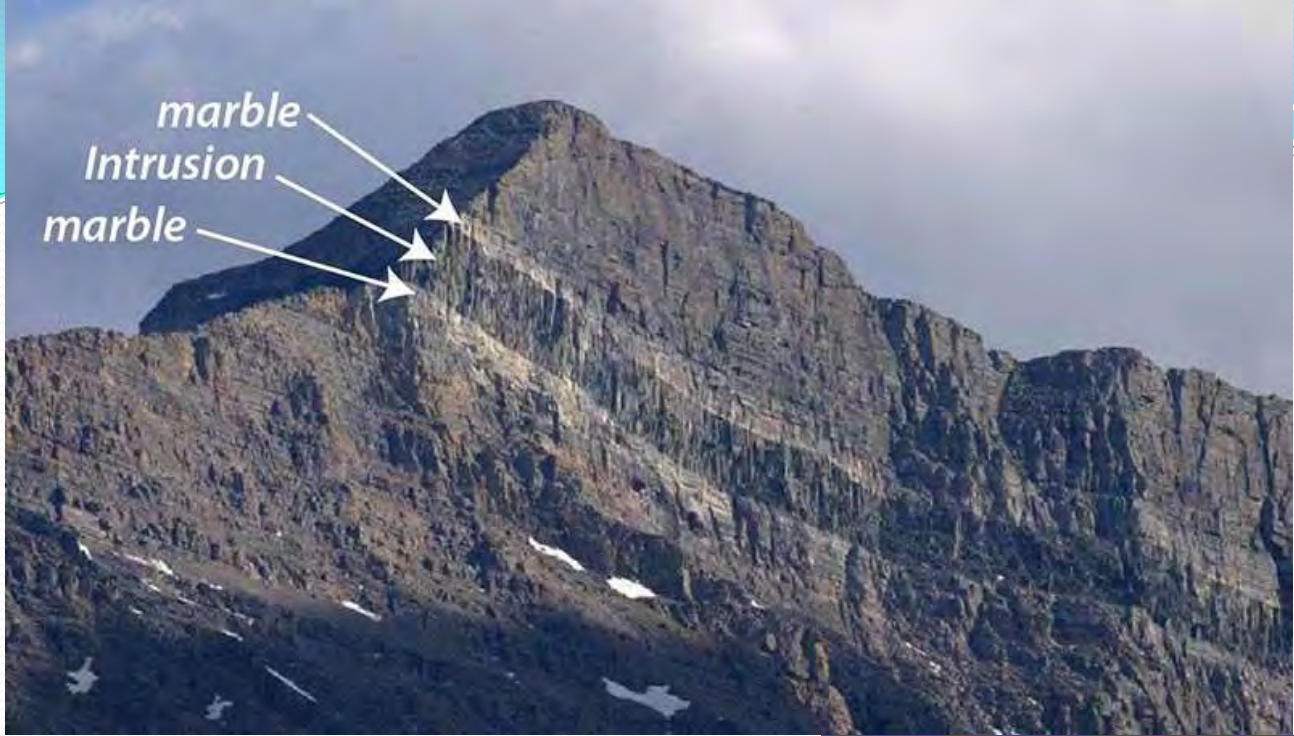
Time

surrounding rock

contact metamorphism

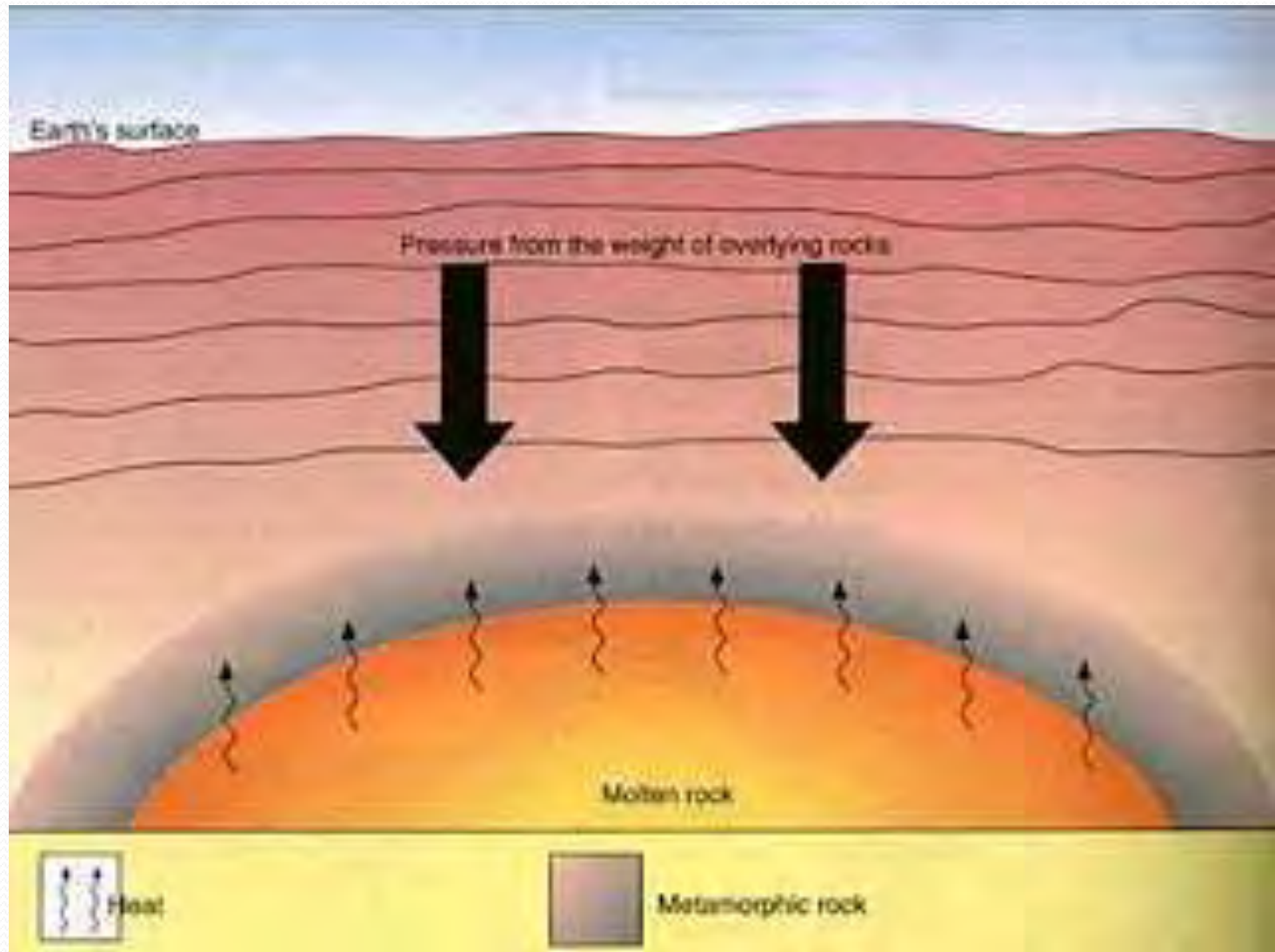
magma





Metamorphic rocks formed by pressure

- Rocks that get squashed between moving land masses change due to the pressure on them.
- Crystals in the rock are flattened or stretched by the pressure.
- Some sedimentary rocks change into metamorphic rock because there is several km's of sediment on top, which causes great pressure.
- Examples: Quartzite, marble, slate

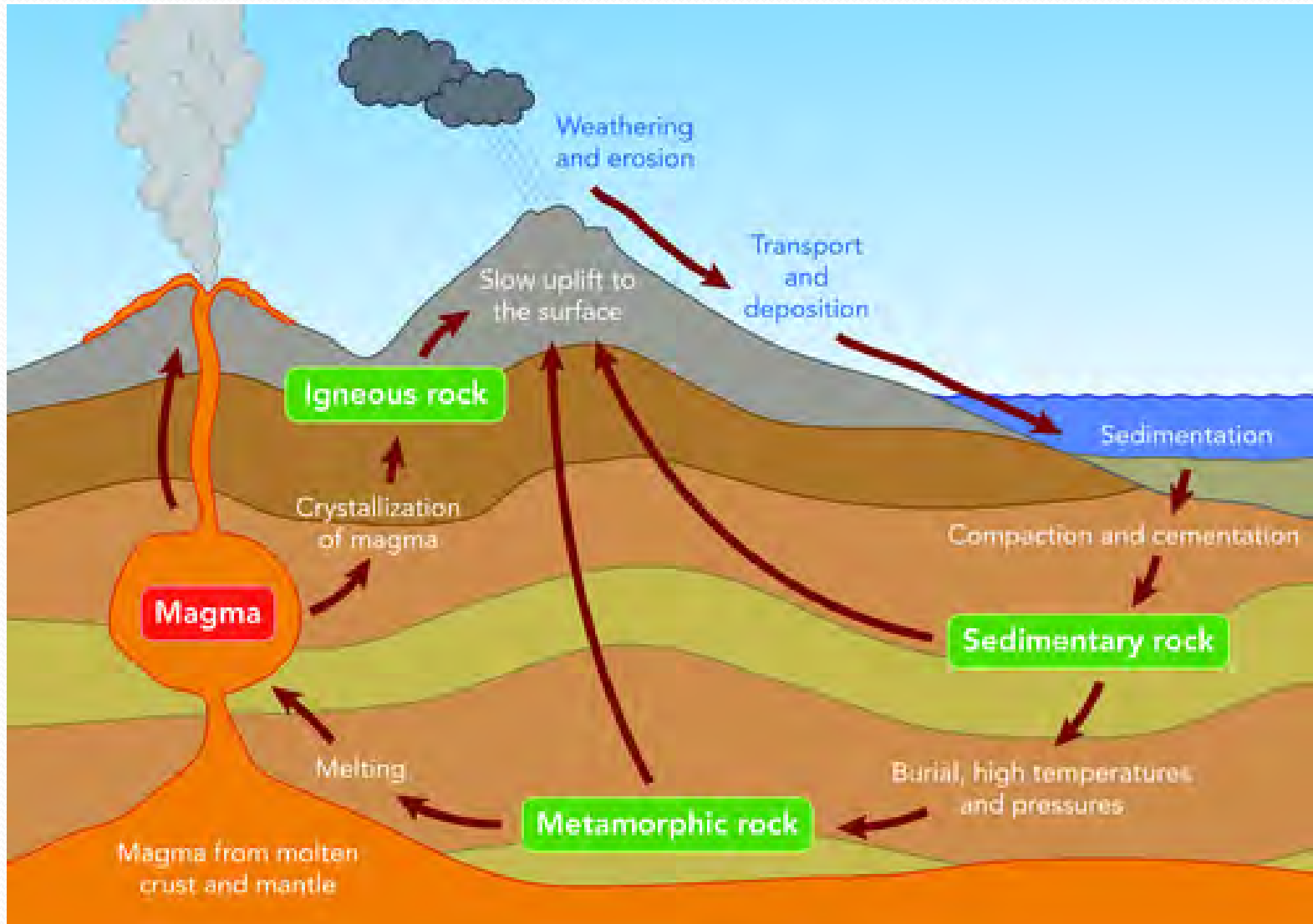


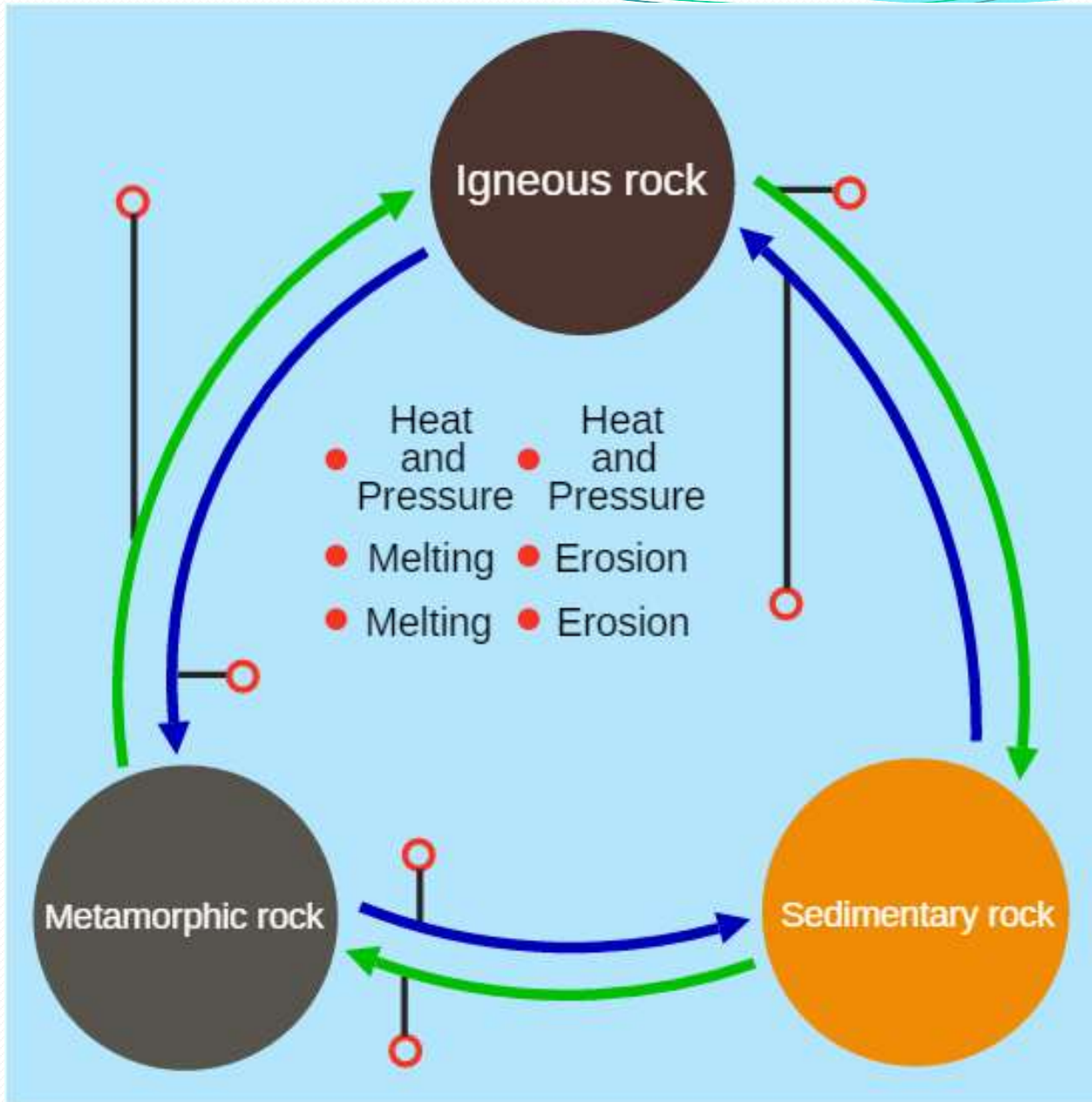


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Unit 3: The Rock cycle

- Rocks melt and break up to form new rocks, this rock cycle happens over hundreds of millions of years, we call this the rock cycle.
- **This cycle involves the following processes:**
 1. Lava cooled to form igneous rock at the earth's surface.
 2. Weathering breaks down rocks at surface
 3. Erosion of rocks creates sediments
 4. Sediments are deposited into the oceans
 5. Compaction and cementation causes sedimentary rocks to form.
 6. Heat & pressure changes sedimentary rock into metamorphic rock
 7. Metamorphic rock is then melted to form magma and the cycle starts over.



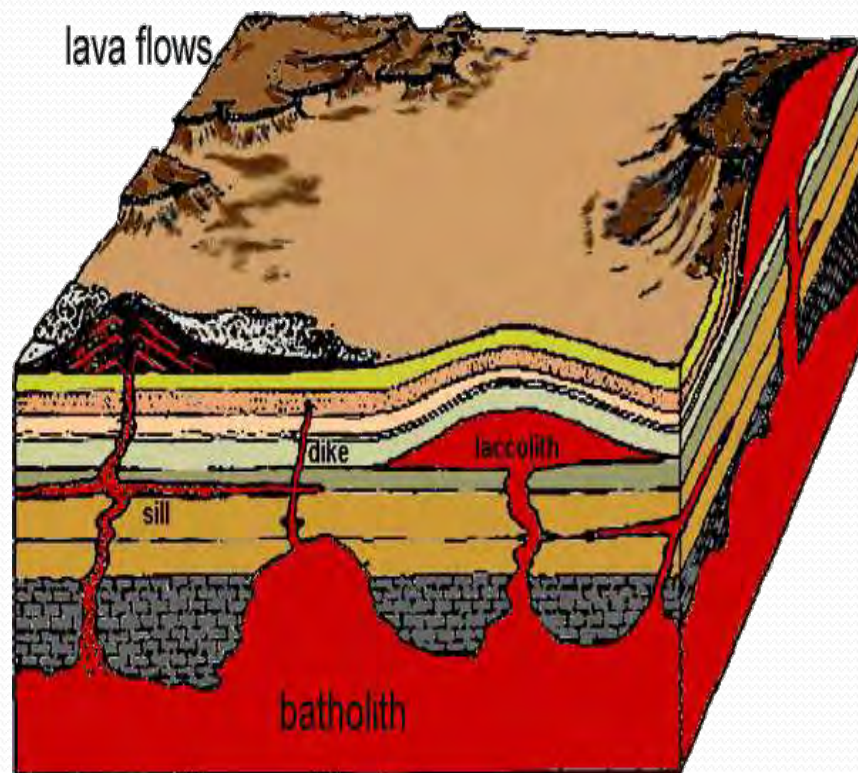


Unit 4: Intrusive igneous activity & features

- The Earth's mantle is made of magma (molten rock), magma is less dense than rock and works its way through cracks and joints to the earth's crust.
- When magma cools it forms igneous intrusions.
- We classify these igneous intrusions according to their shape, size and depth.

1. Batholiths

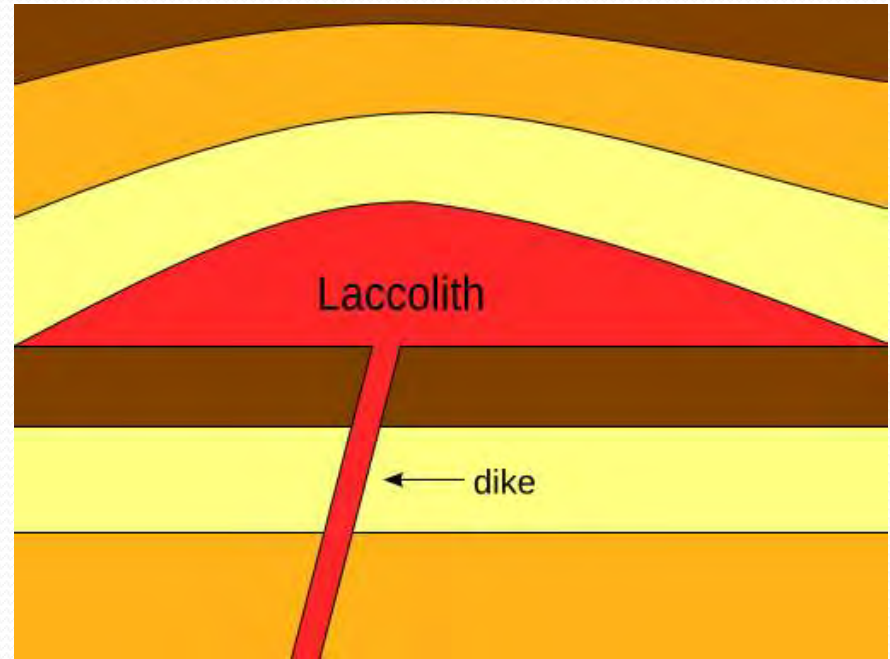
- Batholiths are the largest & deepest igneous intrusions
- They can cover 1000's of km & are associated with continental movements
- Magma cools slowly to form rocks with large crystals, granite is the most common rock associated with batholiths.





2. Laccoliths

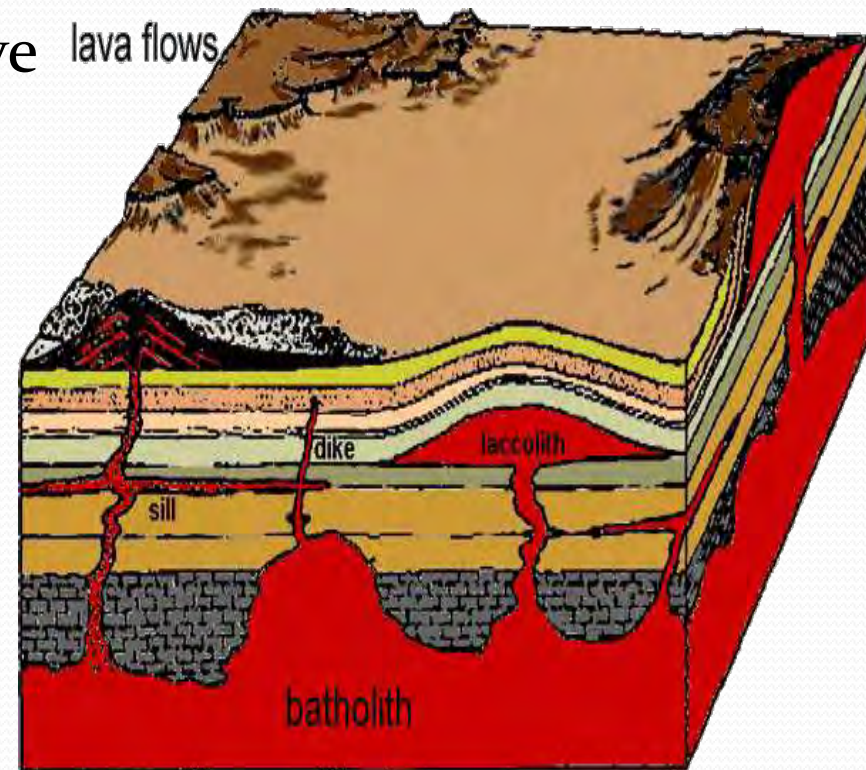
- Laccoliths are dome-shaped intrusions.
- They form when magma is forced between layers of sedimentary rock & pushes up the layers of rock above it.
- Laccoliths can cause mountains to be pushed up.

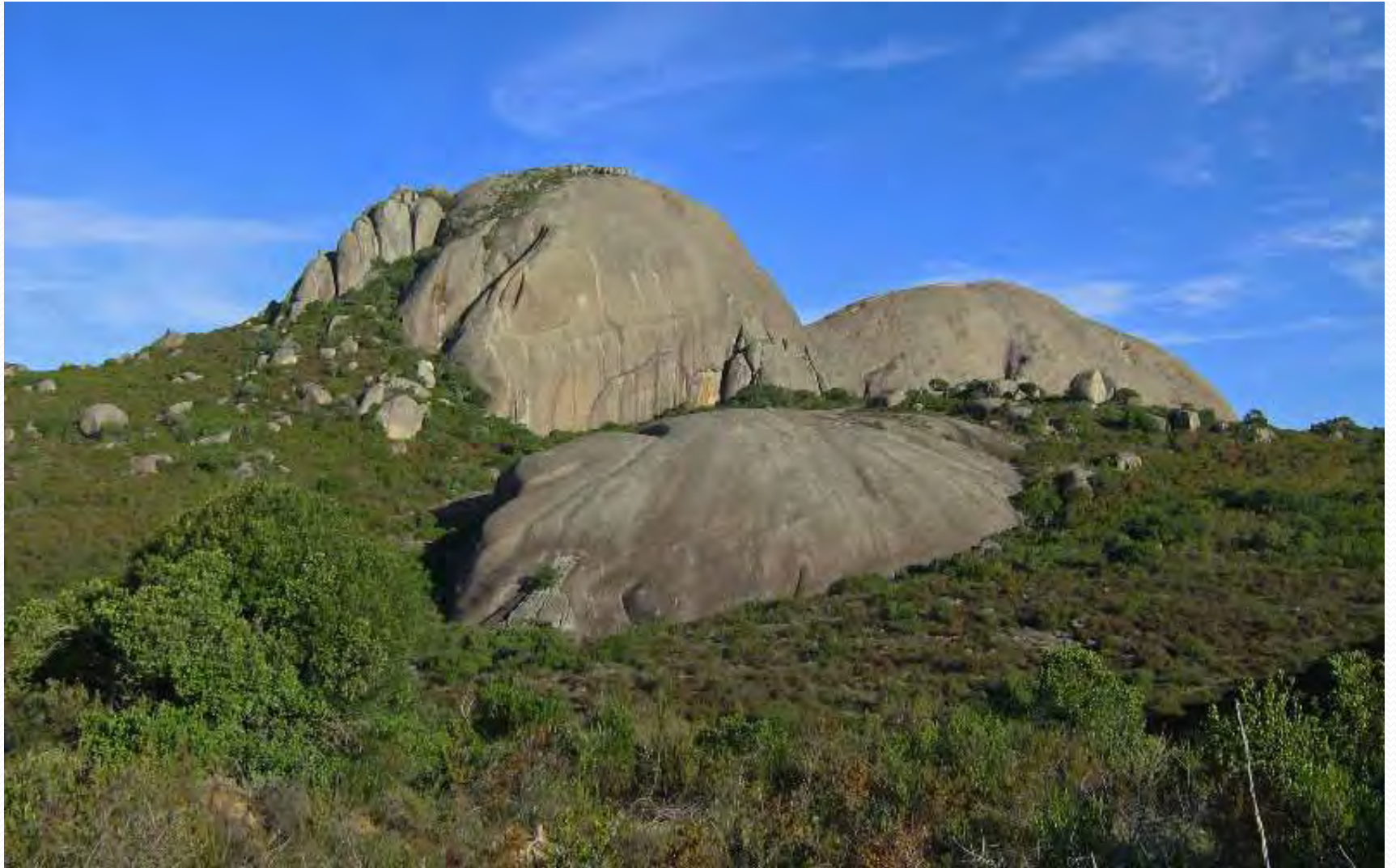




3. Monolith

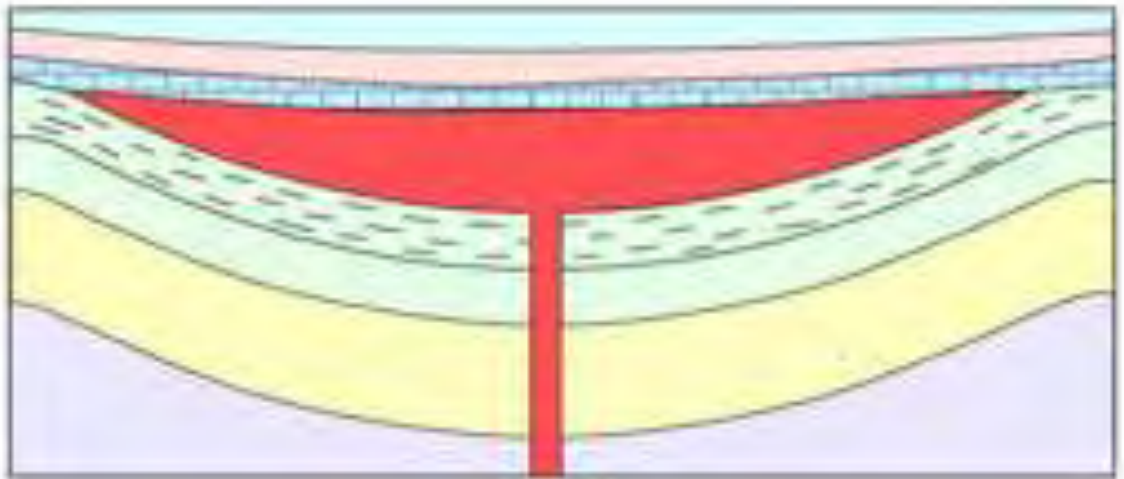
- Monoliths are very large intrusions.
- When exposed on the earth's surface they form a huge area of domed rock.
- Monoliths are batholiths that have been exposed.





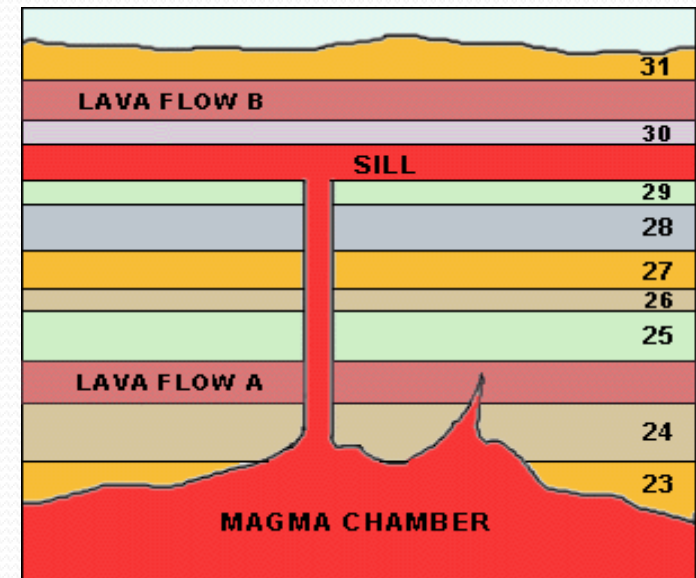
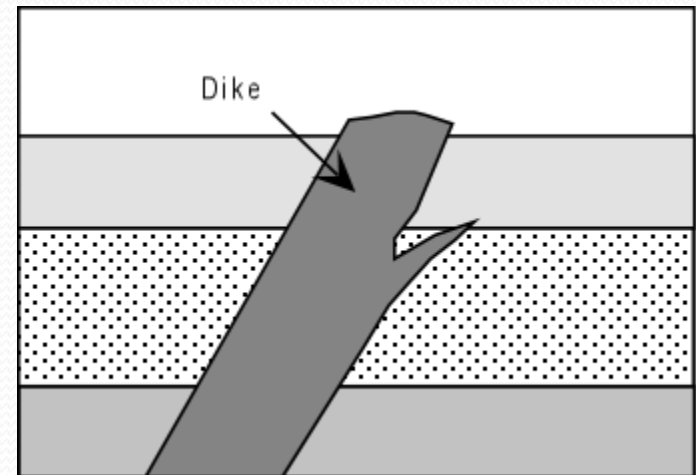
4. Lopolith

- Similar to a laccolith, but the weight from the overlying strata causes the lopolith to sink into a saucer shaped structure



5. Dykes & sills

- Dykes are caused by magma forcing its way vertically through layers of rock.
 - They are usually only a few meters across.
 - Dolerite is a common rock seen in dykes.
-
- Sills are caused by magma forcing its way horizontally through layers of strata.
 - Sills can stretch many kilometers.



Sill

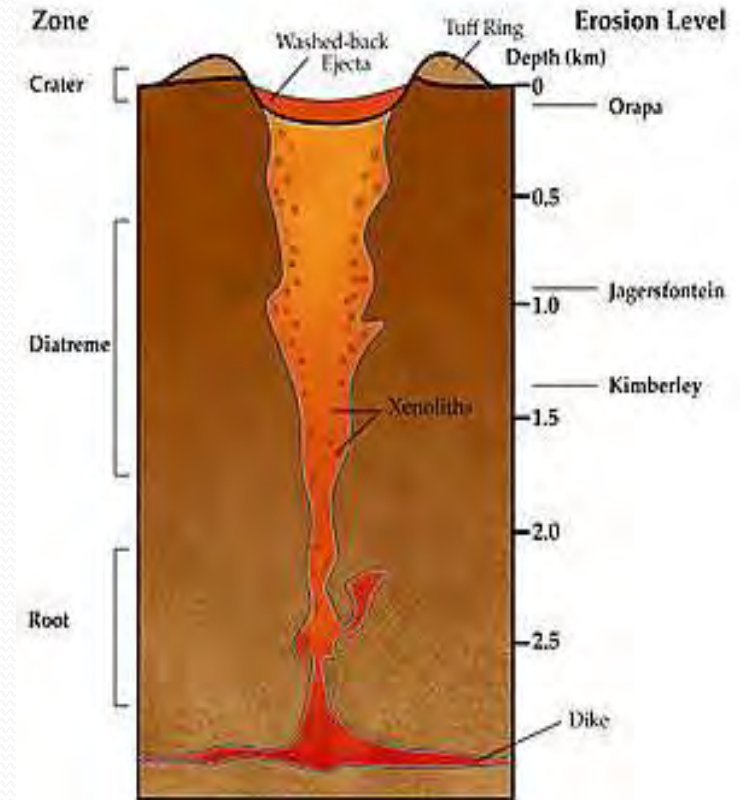


Dyke



6. Volcanic pipes

- Pipes are deep central vents of volcanos
- They are carrot shaped intrusions of solidified magma.
- The igneous rock which forms is often kimberlite, which contains diamonds.





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Unit 5: Landforms associated with different rocks:

1. **Landform and igneous rocks: (refer to figure 3.19 page 136)**
 - Tors – are weathered tops of igneous intrusions, they are rounded columns of rock about 20m tall
 - Lava flows – thin layers of lava from volcanic vents, cover large areas.
 - Caldera – collapsed volcano, often contains a lake
 - Domes/monoliths – appear when large igneous intrusions are exposed by erosion.
 - Volcanic neck – stands out as a column of rock above the land, its made of magma that cooled and became solid inside the cone of the volcano. The rest of the volcano has eroded away.

Tors



Lava flows



Calderas

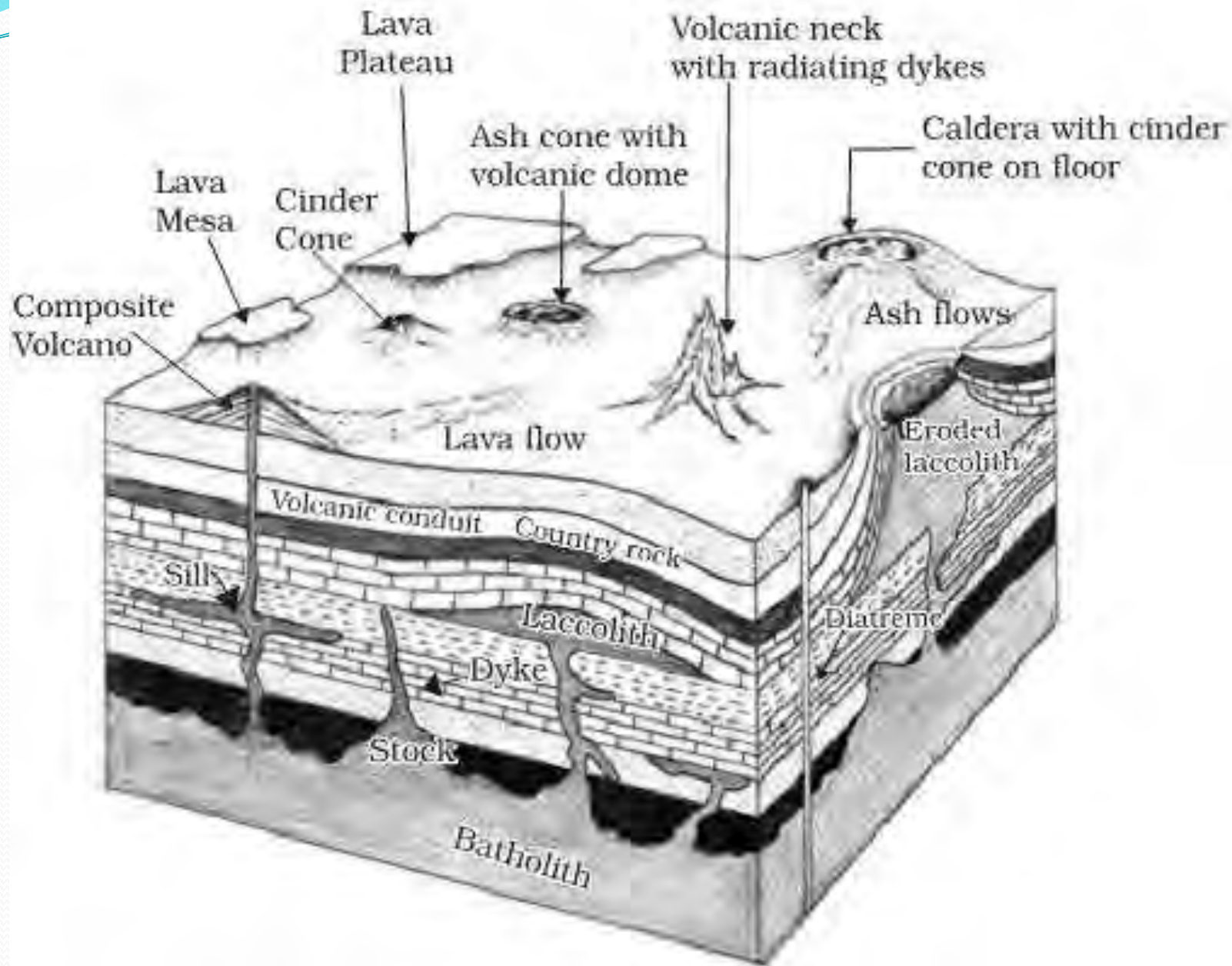


Domes or monoliths



Volcanic neck



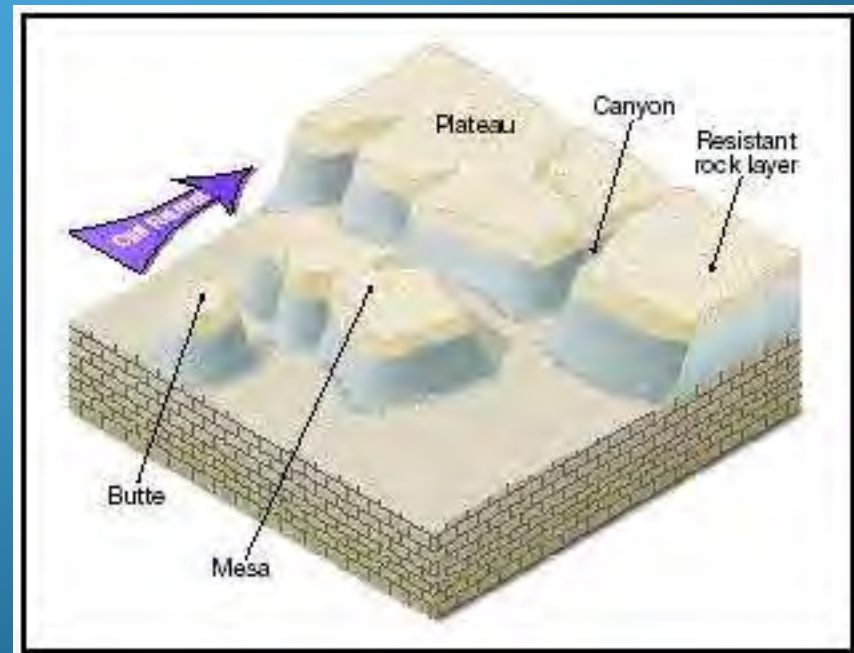


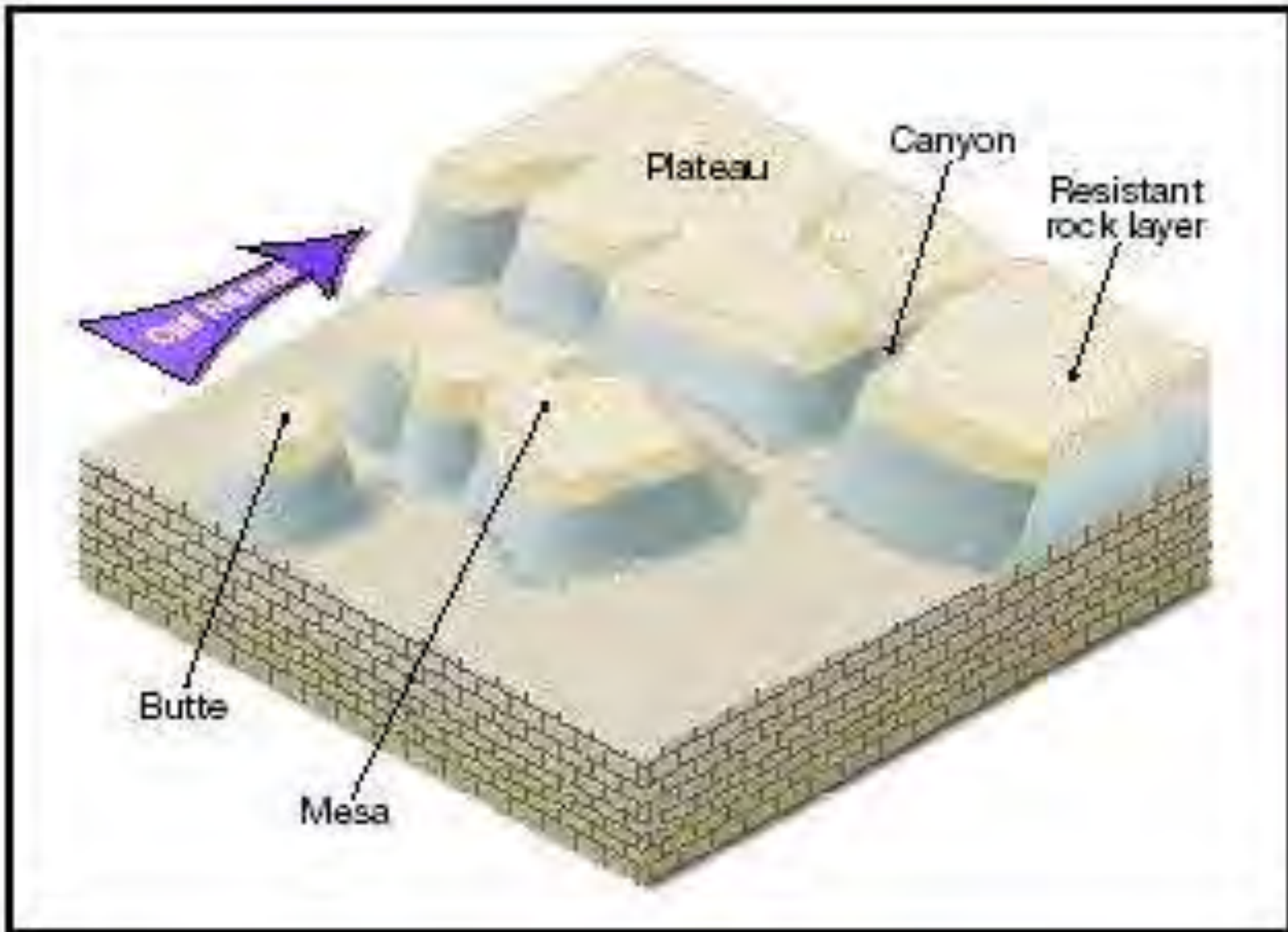
Landforms associated with sedimentary rock

1. Horizontal strata

- Sediments deposited in horizontal layers turn into layers of horizontal rock called strata.
- Some layers are harder and more resistant than others , the softer less resistant rock is eroded away over time.
- The following landforms are associated with horizontal strata:

1. Mesa's
2. Buttes
3. Plateau

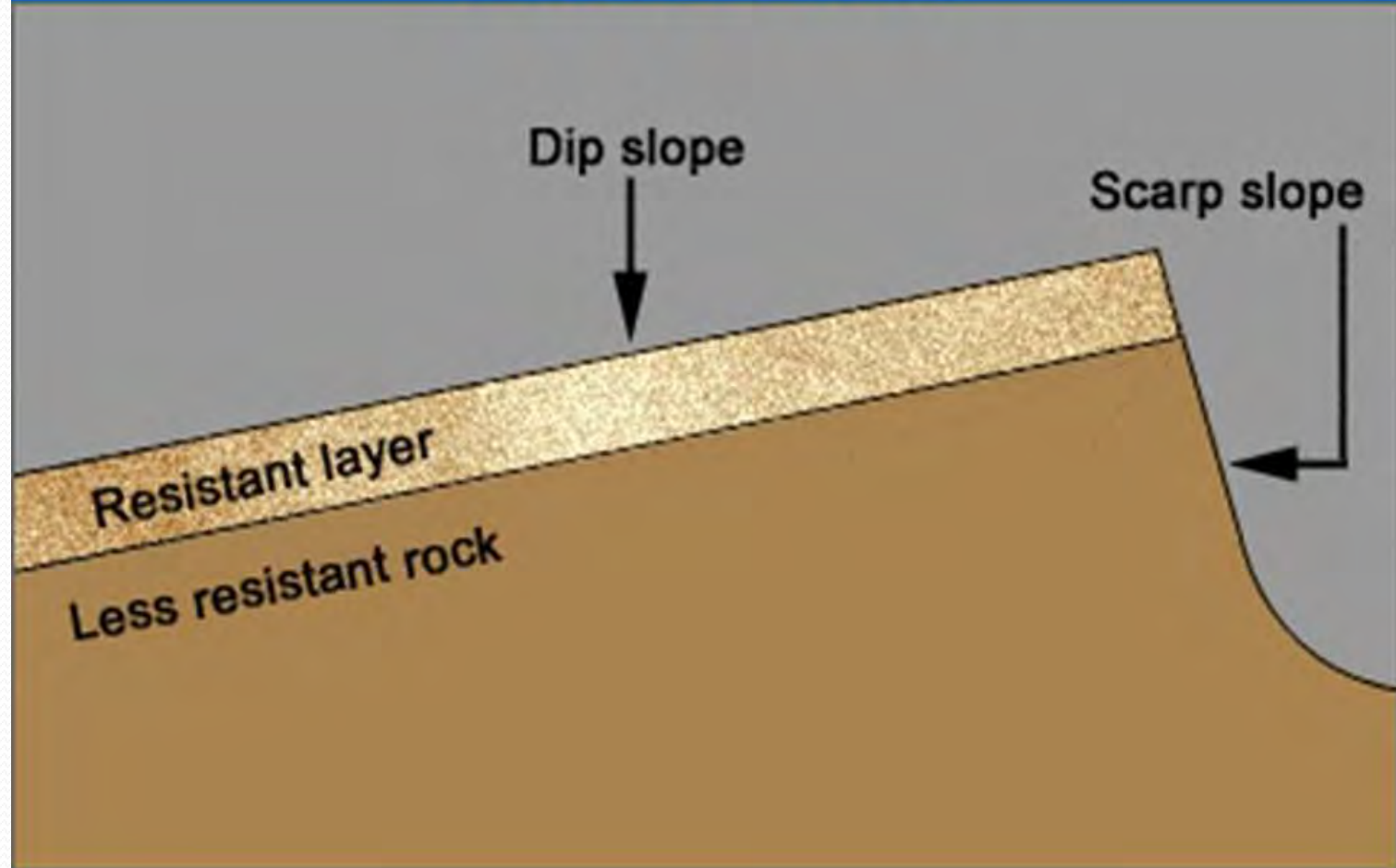




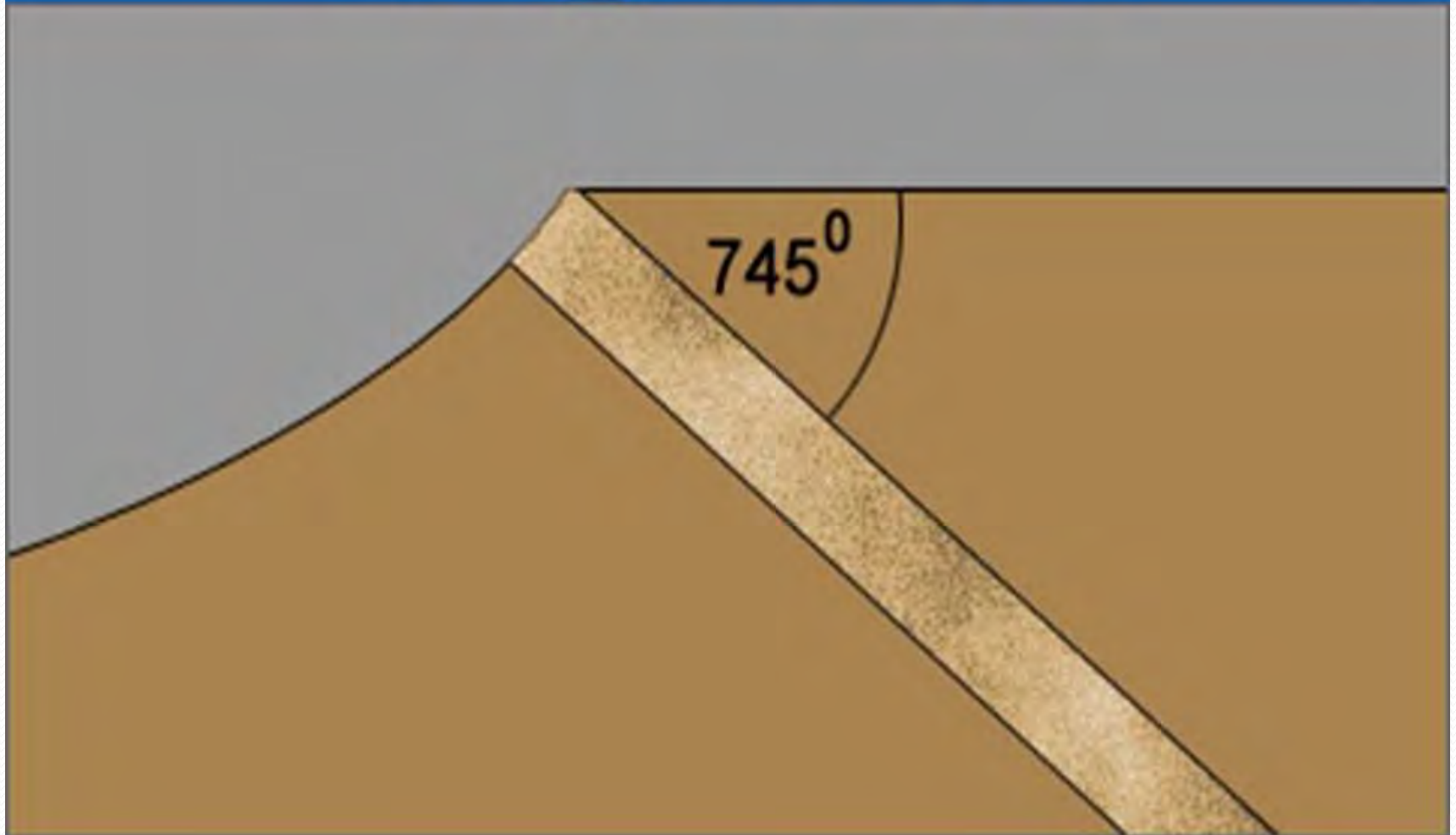
2. Inclined strata

- Sediments can be deposited at an angle, like the edge of a continent as it slopes into the sea, it also results from movement of the earth's crust.
- Strata that's been tilted or inclined erodes and form landforms called cuestas or hogsbacks.
- Cuestas have one steep slope and one gentle slope.
- Hogs backs are also formed from inclined strata, but their slopes are much steeper than a cuesta.

Cuesta



Hogsback



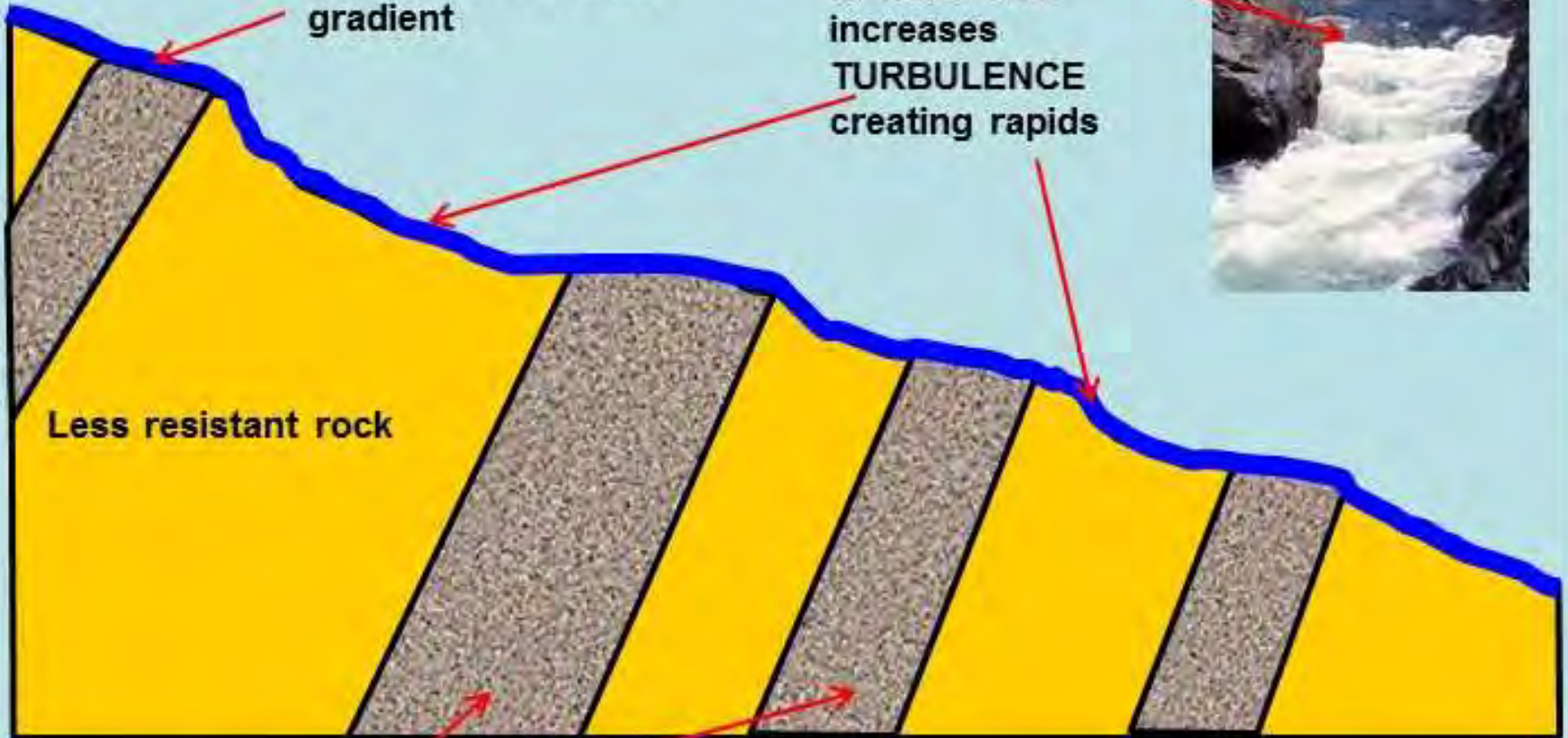
3. Landforms associated with metamorphic rock

- Metamorphic rocks are very hard rocks that are resistant to erosion
- Quartzite for example is harder than sandstone.
- Features created by metamorphic are:
 - Rapids
 - Waterfalls

River Rapids

Rock eroded at a slower rate so lower gradient

Faster erosion rates steepen gradient . This speeds up flow of water and increases **TURBULENCE** creating rapids



Less resistant rock

Bands of more resistant rock

By Rob Gamesby

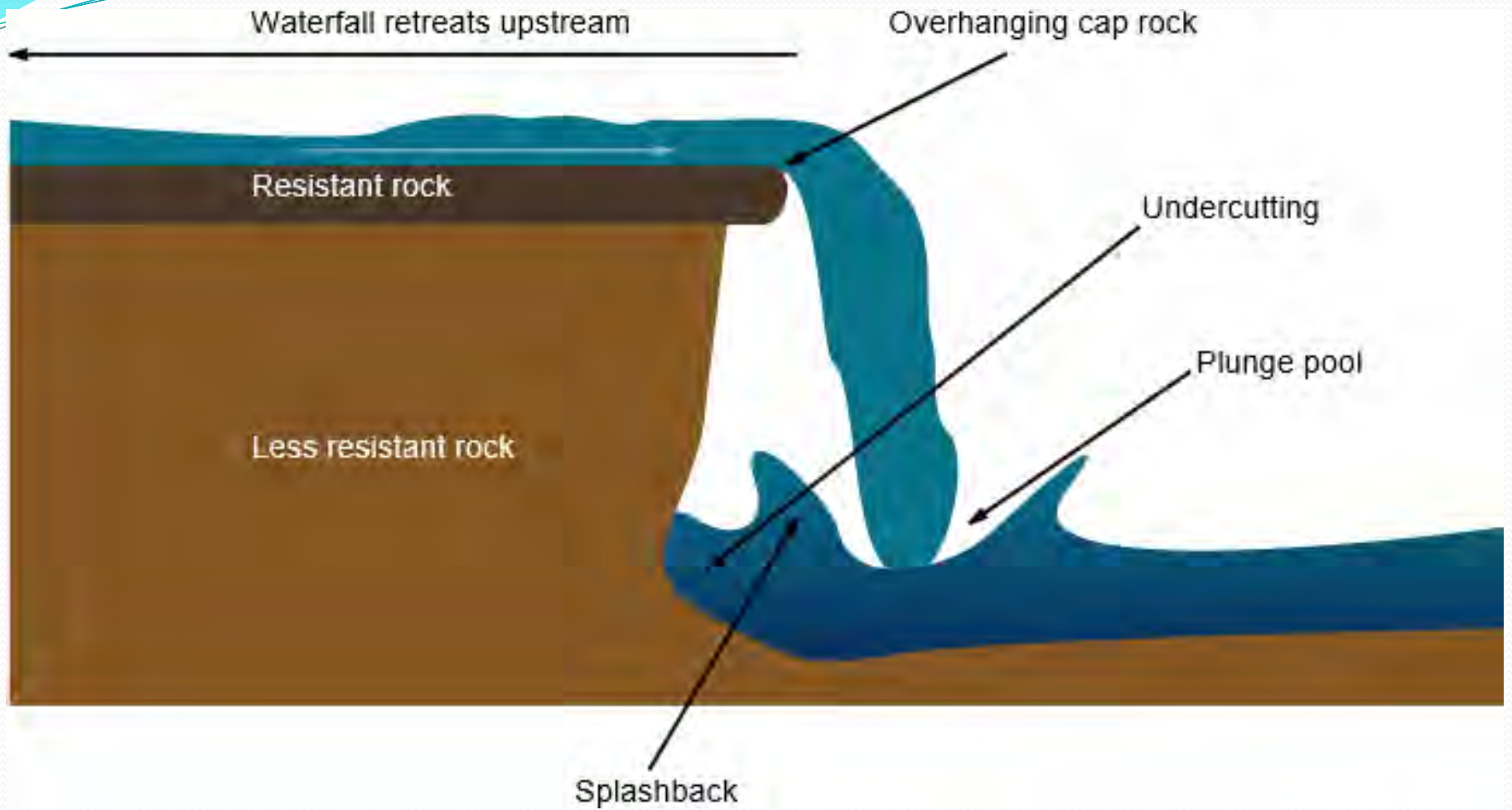


Plate tectonics

- Plate tectonics is a theory based on the movement of the Earth's crust
- In 1915, a German scientist named Alfred Wegener, came up with the theory of continental movement:
- In Alfred Wegener's theory he suggested that the movement of continents changed positions by "drifting" on top of the mantle.
- This "drifting" took place over millions of years.
- The theory suggests that continents were formed from one large landmass that slowly broke up, forming the continents as we know it today.

Pangaea:

- One big landmass called Pangaea, 180/250 million years ago.



PERMIAN
250 million years ago

Laurasia & Gondwanaland

- Pangaea began to break up in Laurasia & Gondwanaland, 175 million years ago



TRIASSIC
200 million years ago

Present continents

- Laurasia & Gondwanaland began to separate 150 – 65 million years ago, slowly forming the continents as we know today.



PRESENT DAY



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Unit 2: Evidence for the movement of continents:

- Alfred Wegener's theory was not supported in 1915 due to lack of evidence.
- In the 1960's scientists began to offer the evidence to support Wegener's theory:
 - Fossil evidence
 - Age & composition of mountains/rocks
 - Ice erosion
 - Paleomagnetism
 - Sea-floor spreading

Scientists found the following evidence:

- Similar fossils of plant & animals on the southern continents
- Rock formations are the same in South America & West Africa
- Ice erosion on much of the south continents, this is only possible if these land masses were close to the South Pole.
- Rocks in ocean ridges are younger than rocks further away, suggesting that ocean floors are moving away from ocean ridges
- When magma cools to form igneous rock, the iron minerals in the magma record the position of the Earth's magnetic field, rocks of the same age should all point in the same direction, but they don't, this shows us that the rocks have changed positions

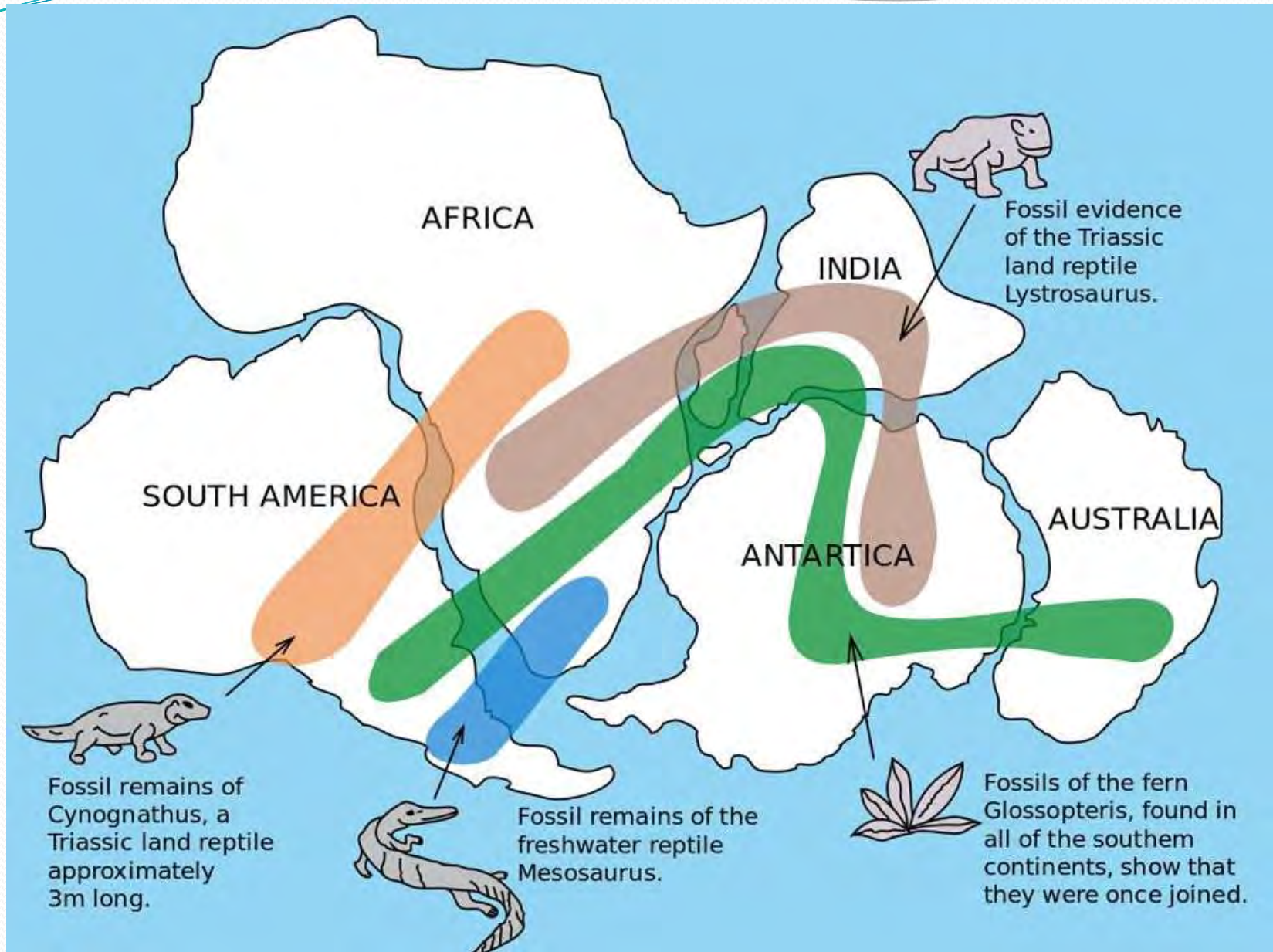
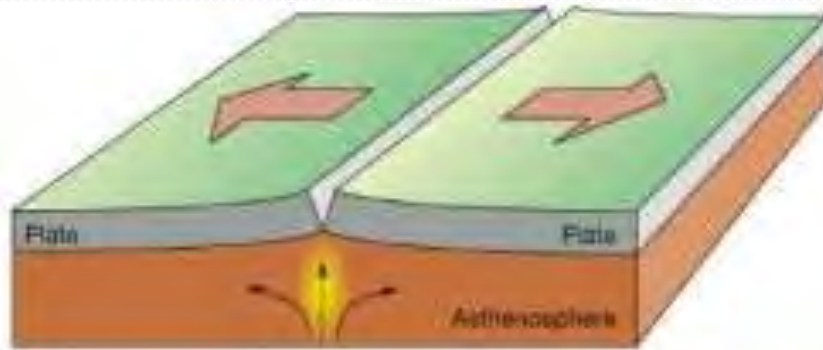


Plate tectonics – explanation for the movement of continents

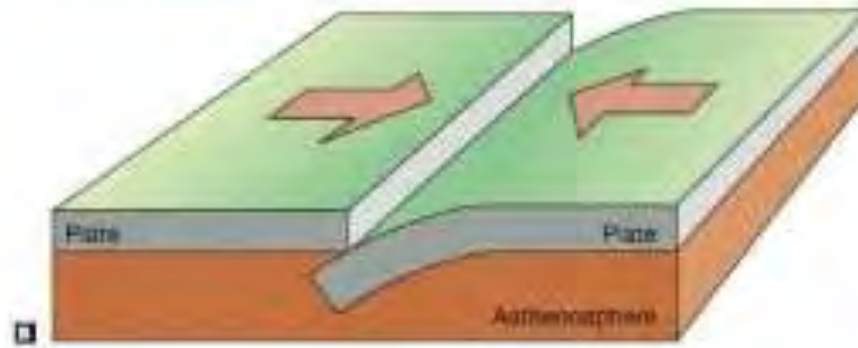
- ❖ Plate tectonics is a theory that suggests the crust of the Earth is divided into **7 giant and 12 small plates** called tectonic plates.
- ❖ These plates are made up from continental crust and ocean crust they move a few centimeters each year
- ❖ Forces within the mantle force plates to move
- ❖ The edges of the plates are called plate boundaries, movement is most noticeable at the plate boundaries.

3 types of plate boundaries

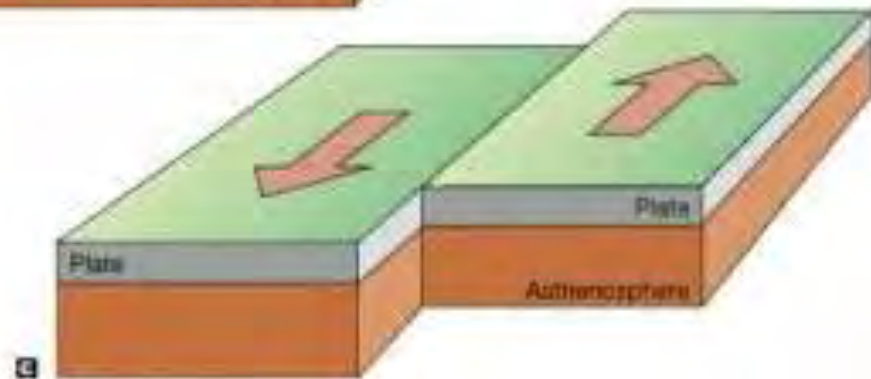
- *Divergent boundaries* – plates moving apart, magma fills the space and new crust is created (volcanic activity)
- *Convergent boundaries* – plates moving together, one plate is forced under another into the mantle, this plate melts causing earthquakes & volcanos
- *Transform boundaries* – plates grid past each other, this movement is associated with earthquakes



a



b



c



Activity 3 page 145

The mechanics of plate movement

- Scientists believe that there are convection currents that move away from divergent plate boundaries.
- Convection currents – circular movements of gases or liquids, caused by heating or cooling.
- These currents drag the earth's crust in the direction in which they move.
- See page 146

Unit 5: Landforms associated with plate boundaries

Global Distribution of Plate Boundaries



Divergent
↔
Extension

Convergent
→ ←
Compression

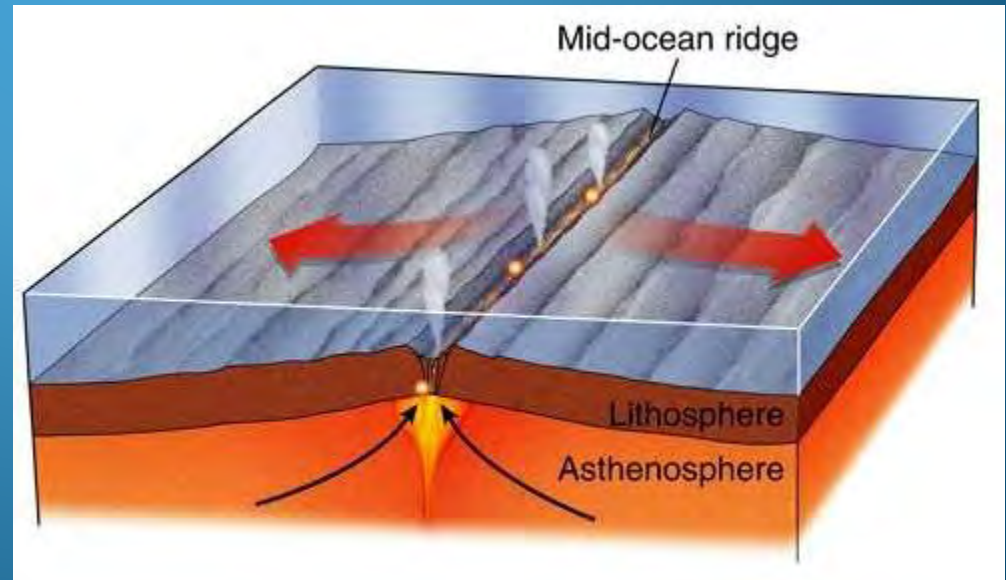
Transform
↔
Shear

Divergent plate boundaries & the landforms

- There are 2 kinds of divergent plate boundaries:
 1. Divergent plate boundaries between ocean plates
 2. Divergent plate boundaries within continental crust

1. Divergent plate boundaries between two ocean plates

- A **mid ocean ridge** is the main feature of a divergent plate boundary between two ocean plates.
- The volcano's erupting at the plate boundaries create mid ocean ridges.
- The Mid Atlantic Ridge forms the largest chain of mountains in the world.

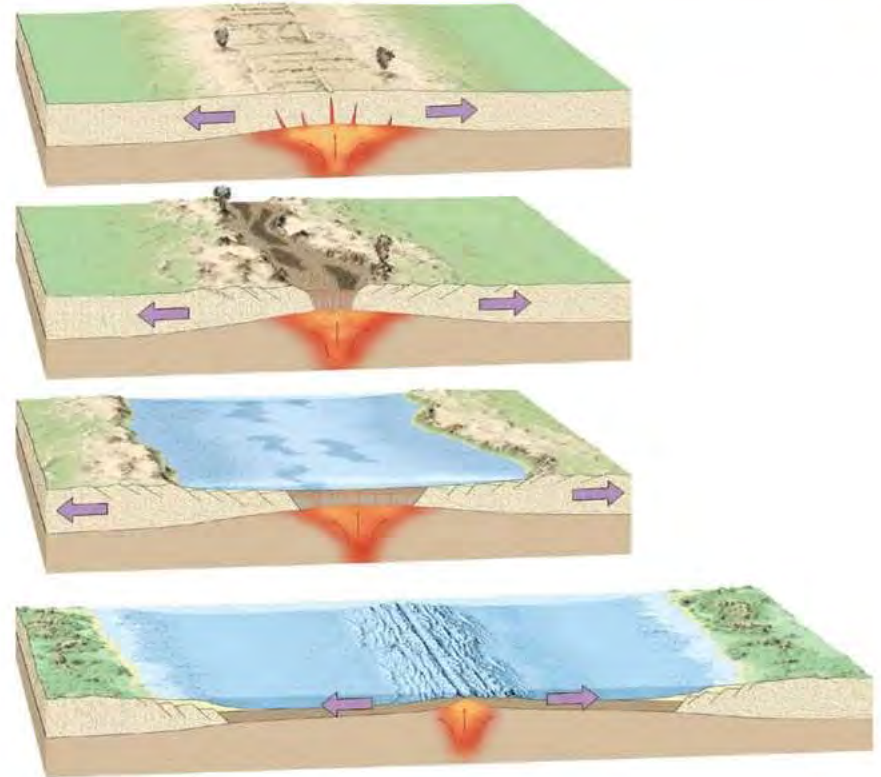
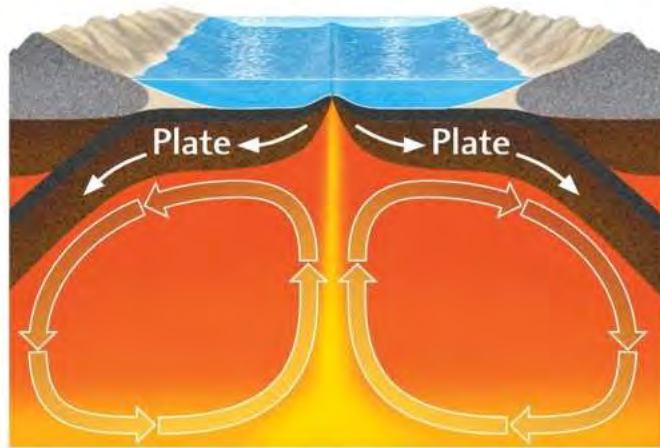
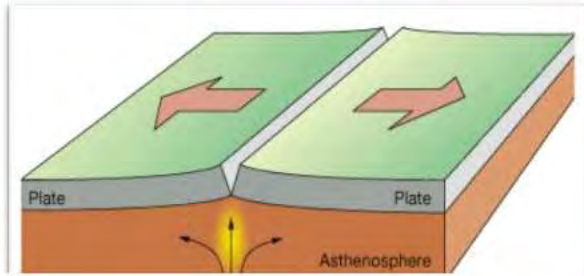


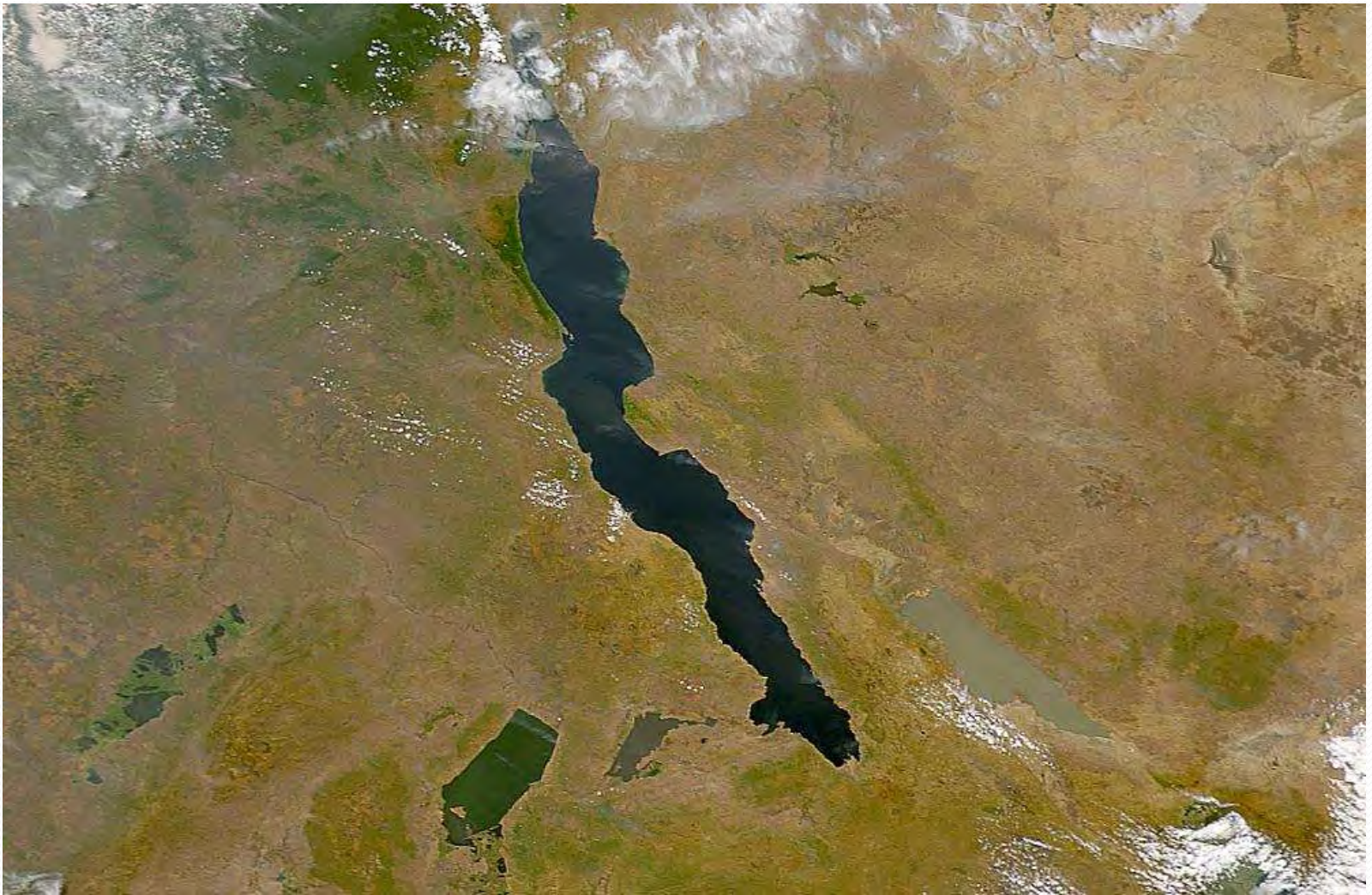
2. Divergent plate boundary involving continental crust

- **A rift valley** is the main feature of a divergent plate boundary involving continental crust.
- When continental crust splits & separates, 2 continental plates will form.
- New ocean crust fills the space between them.
- Pressure causes blocks of land to tear from the crust and slip downwards this process is called **ripping**.
- **East African rift Valley** – is said to be the beginning of the split that will divide Africa into two new plates.

Divergent Plate Boundary - Process of Rifting

Tectonics





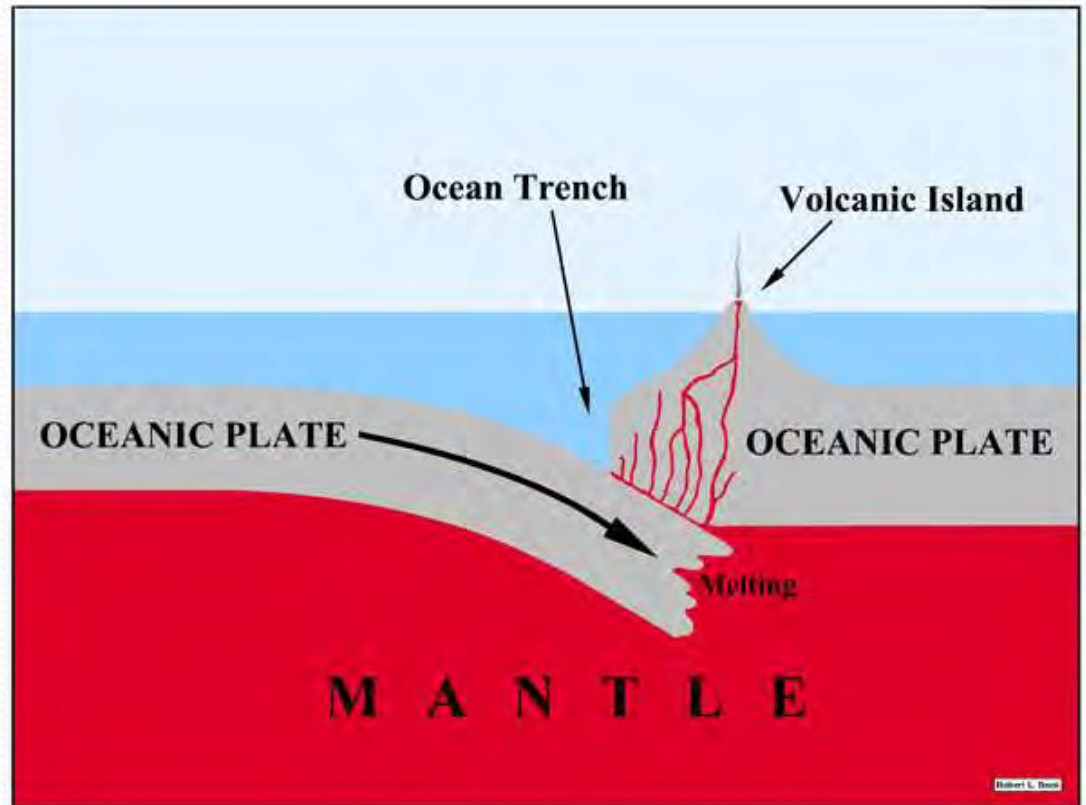
2. Landforms associated with convergent plate boundaries

- There are 3 types of converging plate boundaries

1. Convergent plate boundary between 2 ocean plates
2. Convergent plate boundary between an ocean plate and continental plate
3. Convergent plate boundary between 2 continental plates

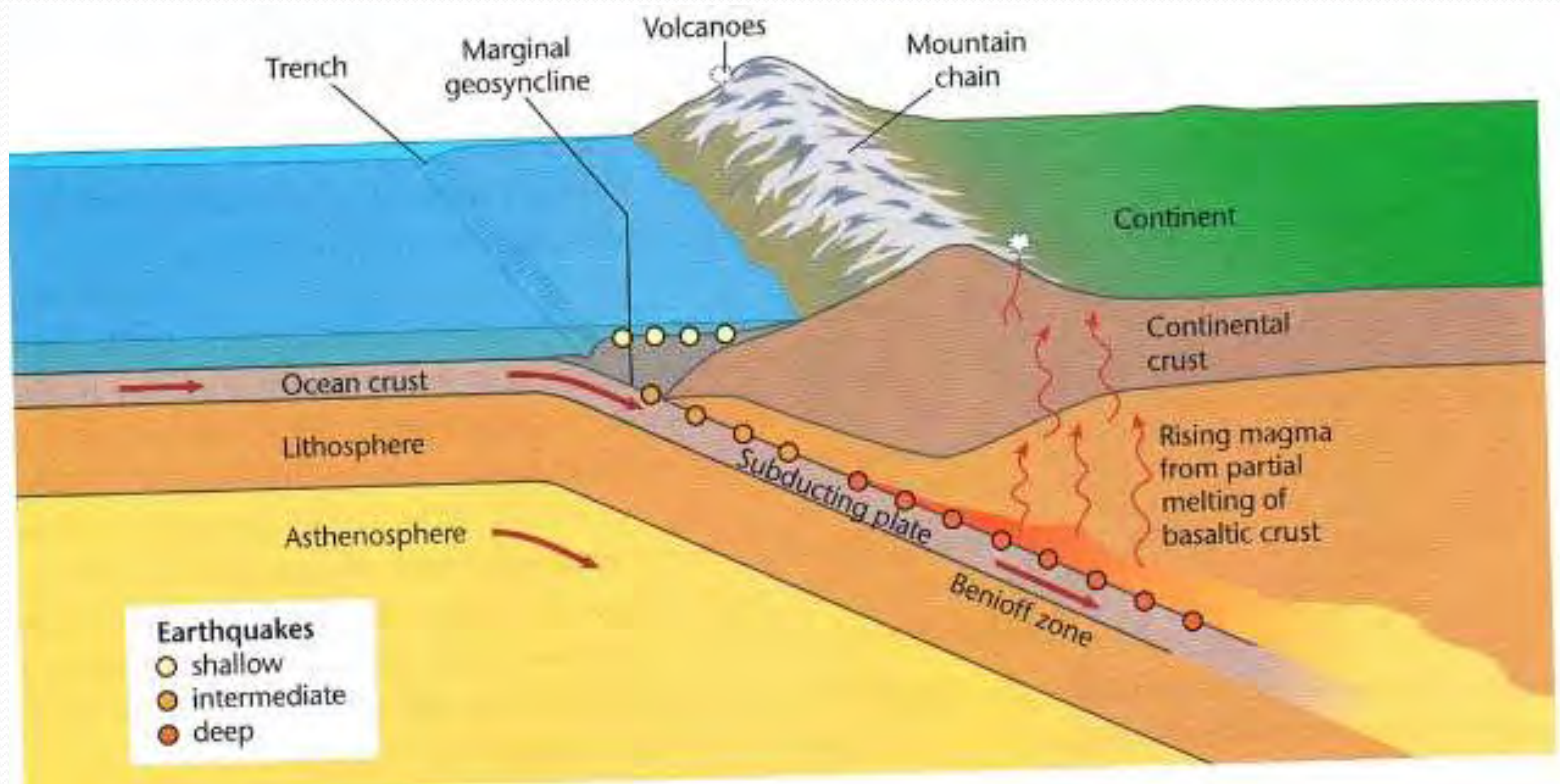
1. Convergent plate boundary between ocean plates

- When 2 oceanic plates converge, 1 plate is pushed under the other creating volcanic islands.



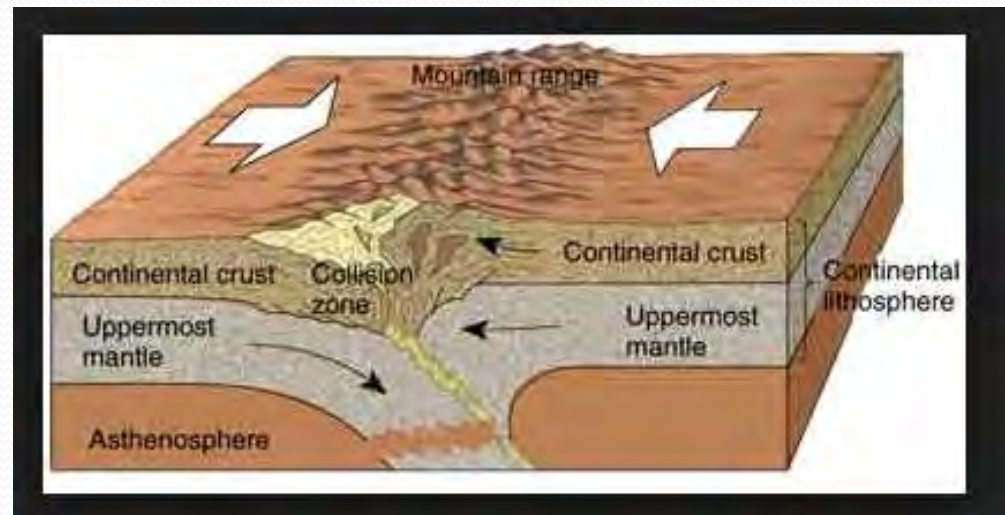
Convergent plate boundary between an ocean plate and continental plate

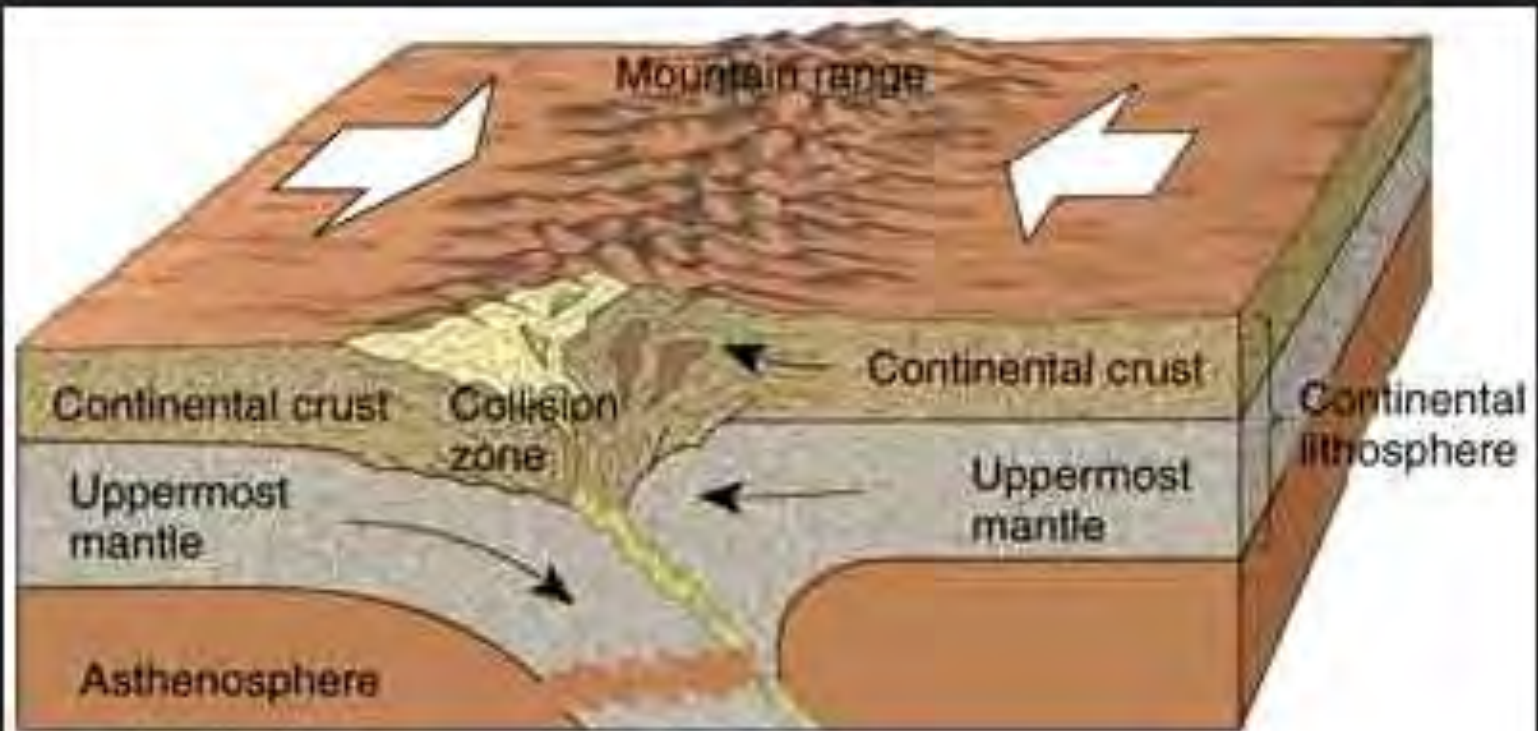
- When oceanic plate is pushed under continental plate a range of mountains is formed .



Convergent plate boundary between 2 continental plates

- When 2 continental plates converge, neither can subduct as they are made of similar material.
- This results in the 2 plate being forced upwards and a large mountain range is formed



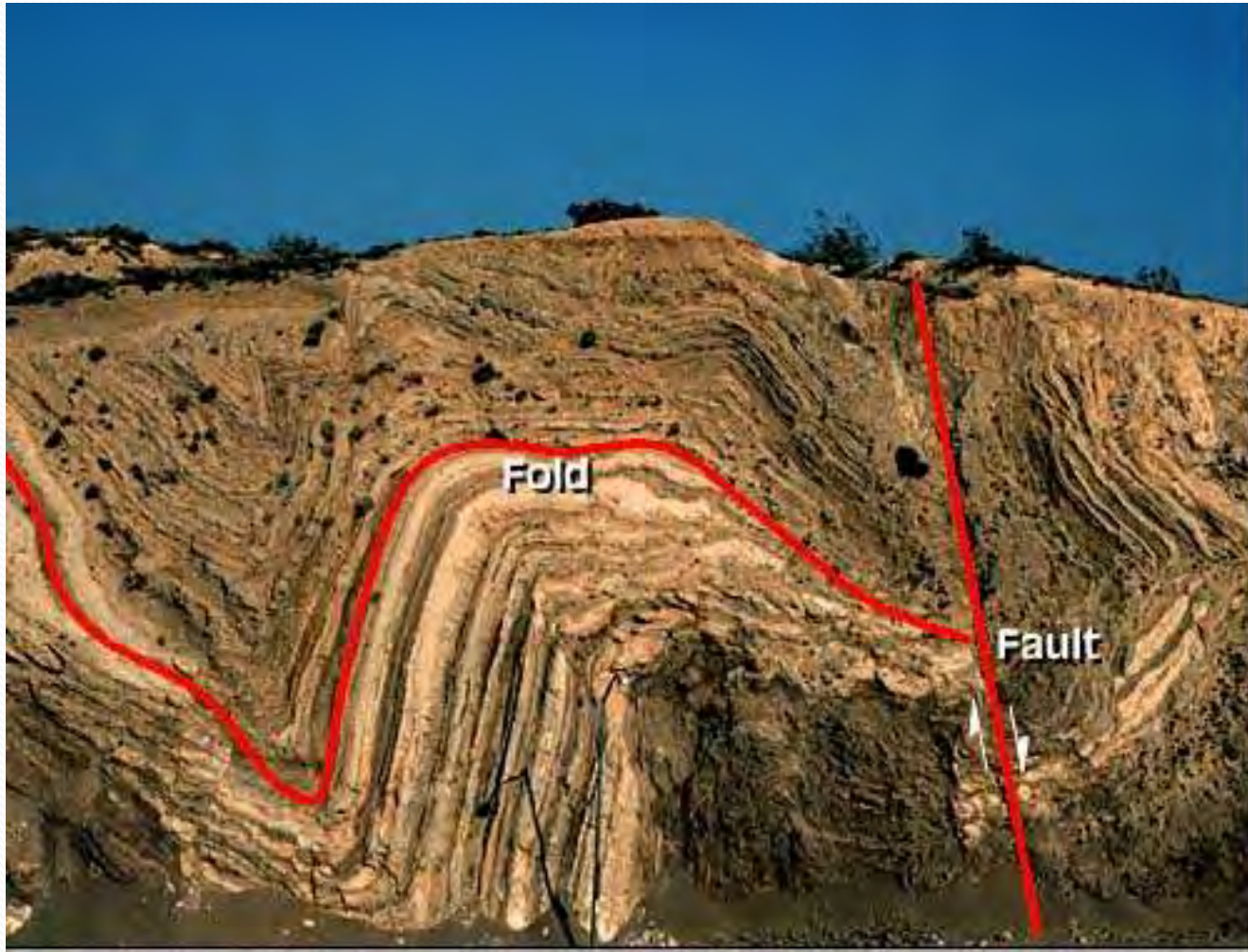


3. Landforms associated with transform plate boundaries

- Earth's crust is neither created nor destroyed along a transform boundary
- Two plates grind past each other.
- The San Andreas fault in California is on a transform plate boundary.
- The North American plate is moving SE while the Pacific plate is moving NW at about 5 cm per year.

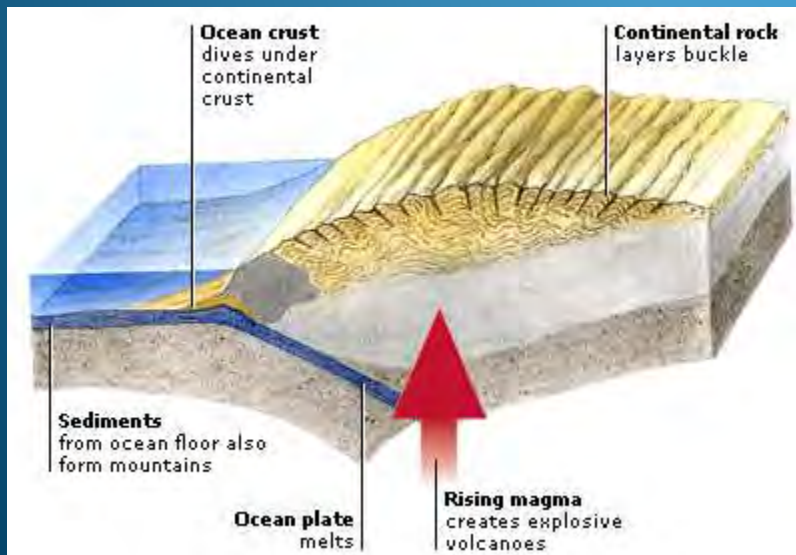


Folding & faulting



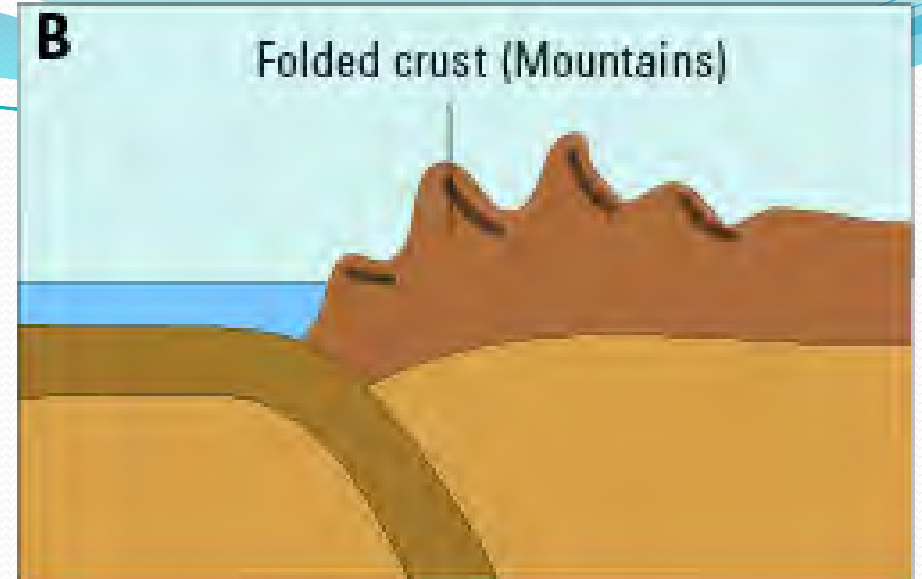
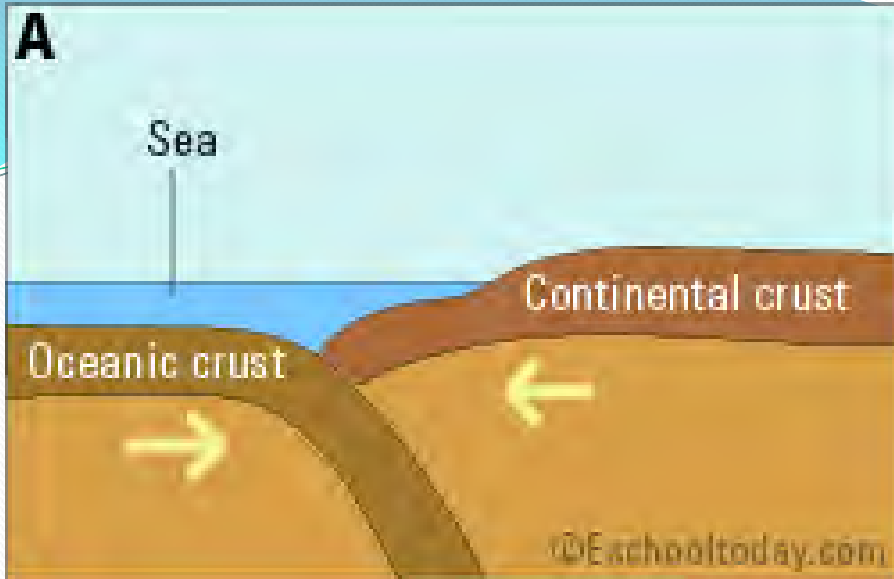
1. Folding

- Rocks that have been physically folded by forces associated with the movement of the continents.
- Imagining a set of folded blankets are pushed up against a wall that's what happens with the formation of fold mountains.
- We call mountains formed in this way fold mountains.



The formation of fold mountains

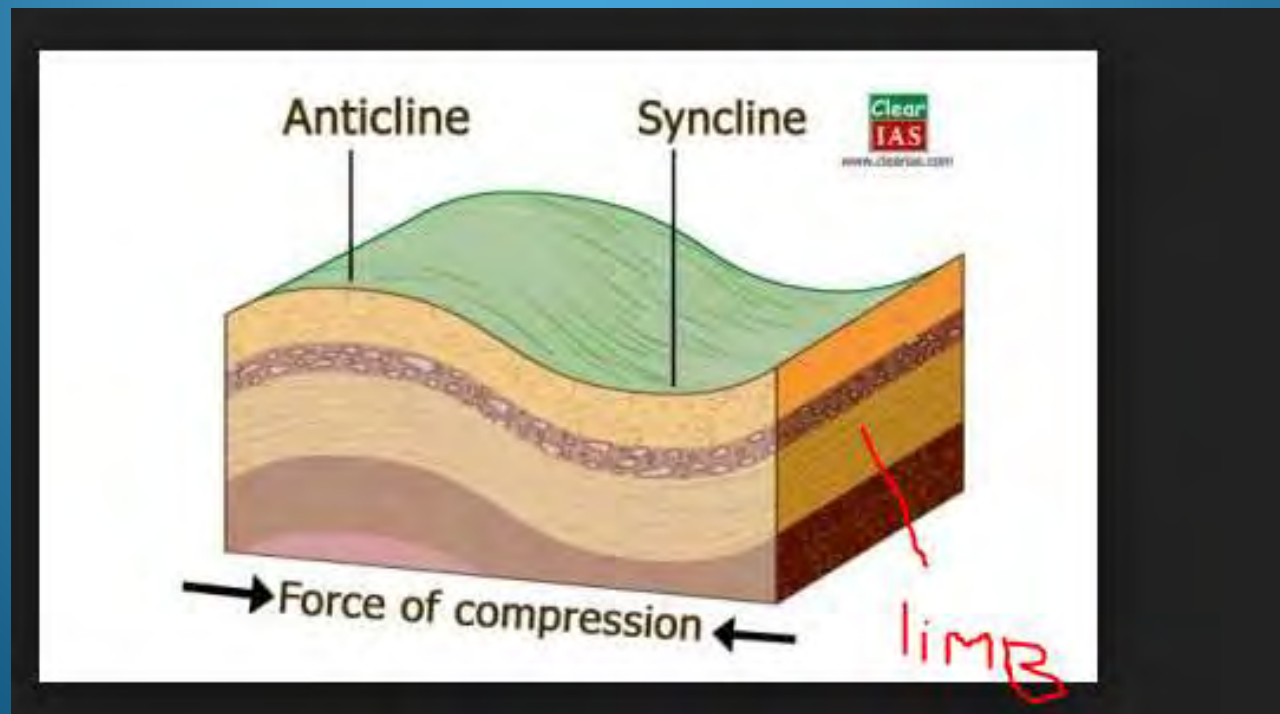
- Fold mountains occur near convergent plate boundaries.
- When plates collide, the thick sedimentary layers of rock strata are pushed together onto the land.
- The rock layers buckle & fold due to the pressure.
- Fold mountains are young in geological time
- Older fold mountains are lower as they have been exposed to weathering.
- The highest mountains in the world are fold mountains
- The Alps for example.



Landforms associated with folding

Anticlines and Synclines

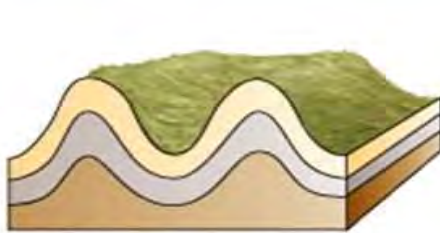
- When rocks fold you get a peak and a trough like a wave.
- The peak is the Anticline
- The trough is the Syncline
- Each side of the fold is the limb.



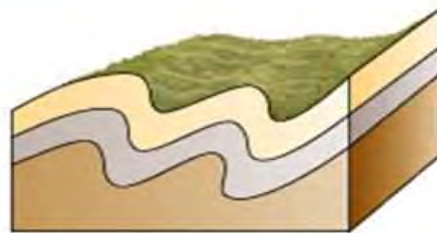
Types of folds

Folds

Five common types of fold geometries
(Fig. 9.20, p. 257)



A. Open (symmetrical)



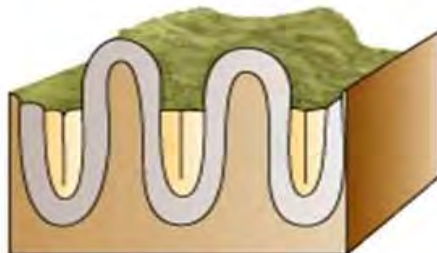
B. Asymmetrical



C. Overturned



D. Recumbent

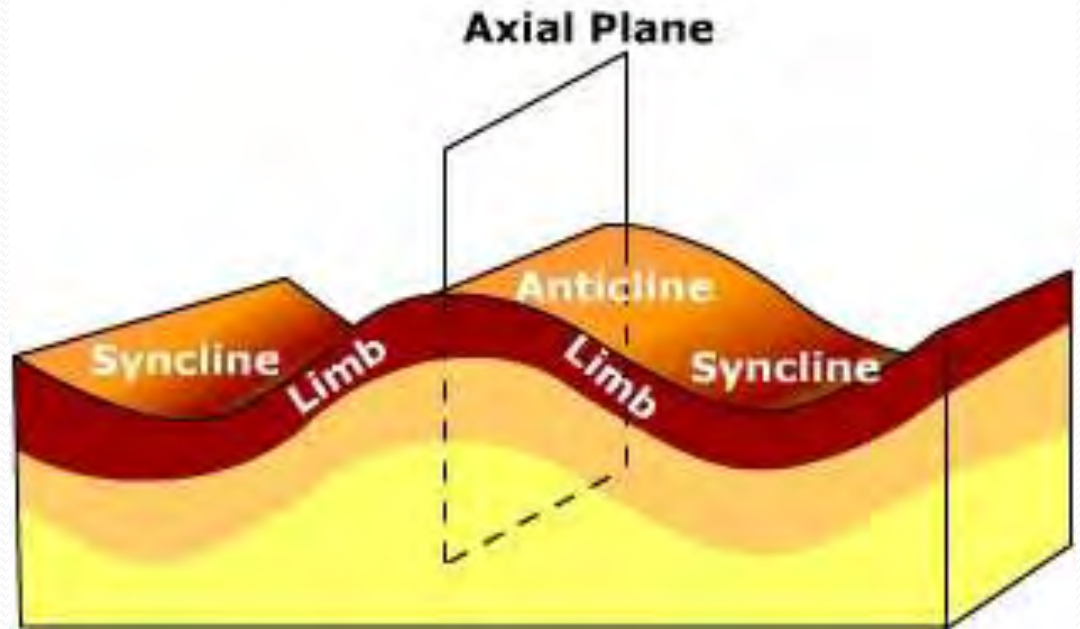


E. Isoclinal

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1. Symmetrical folds

- Have equal limbs
- Have the same amount of pressure from both sides



2. Asymmetrical folds

- These folds appear to lean to one side.
- Pressure was greater from one side



3. Overturned folds

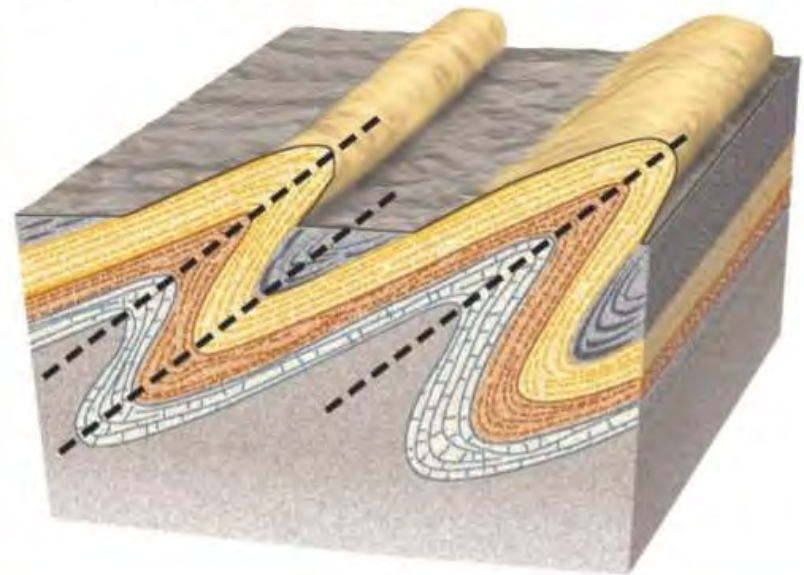
- Folds that are leaning over other folds

Overturned Folds



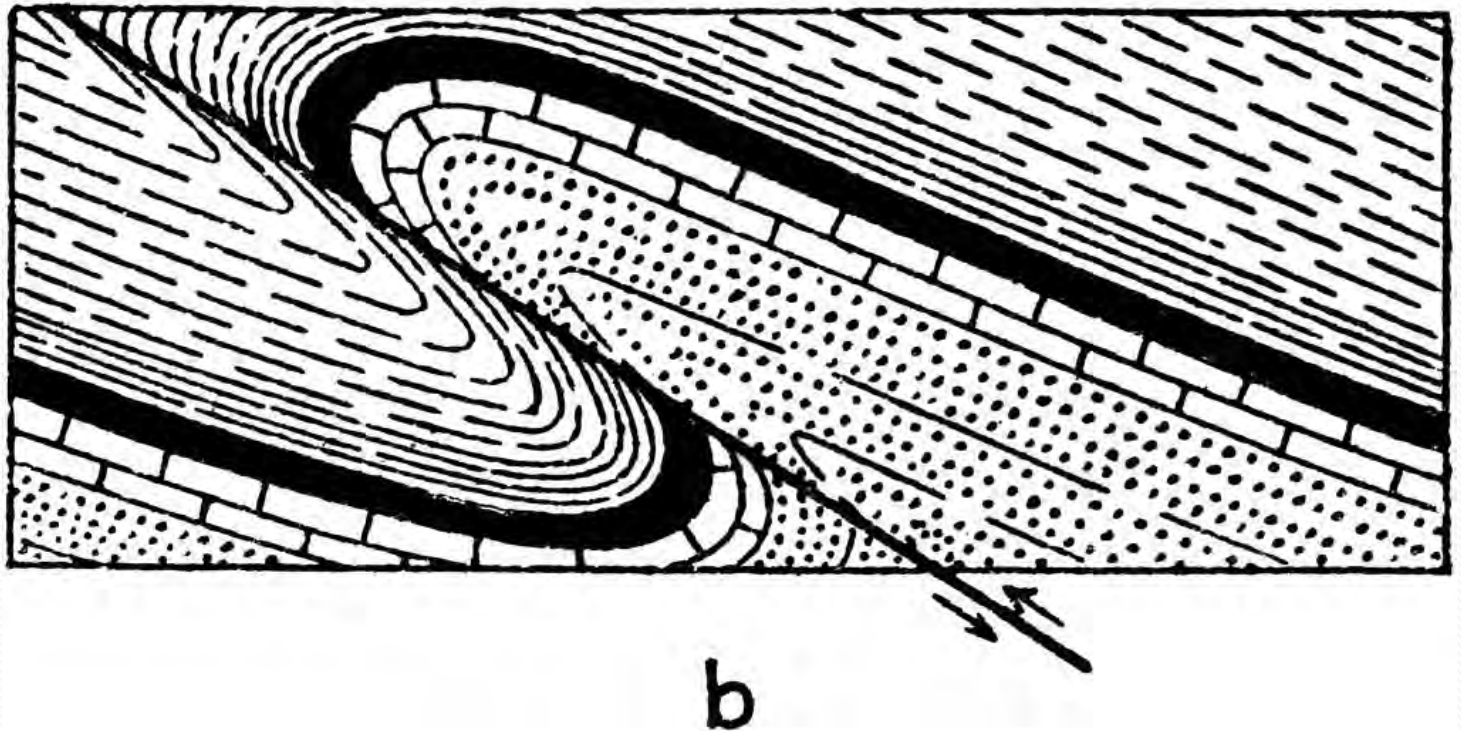
Fig. 10.1

Overturned folds

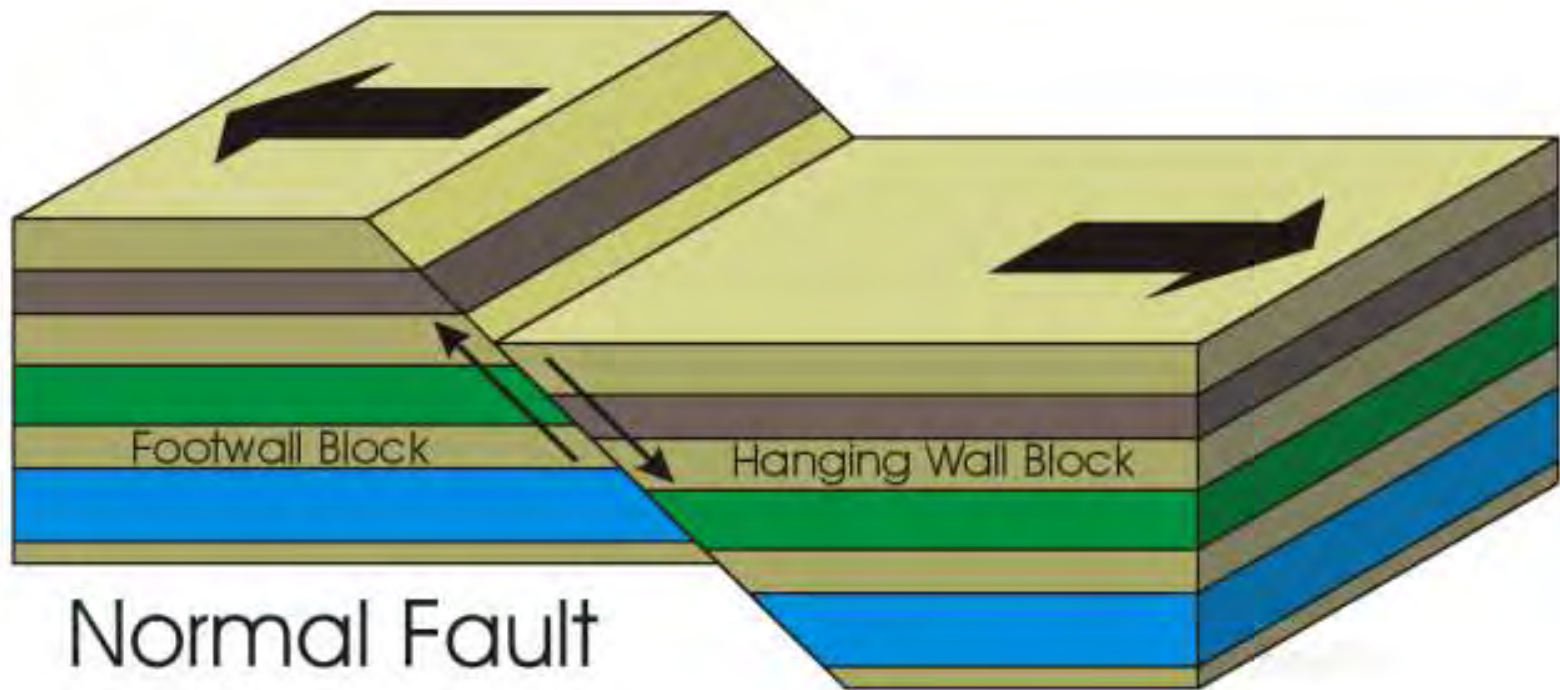


4. Overthrust folds

- Occur when pressure cause the strata to fracture
- One side of the fold slides along the line of fracture called a fault.



Faulting



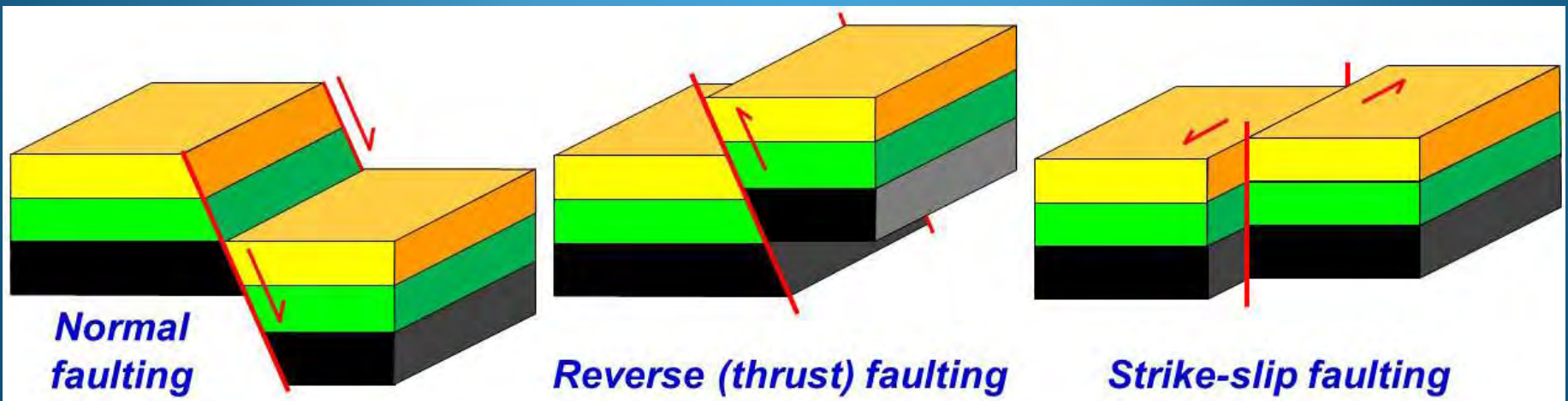
Faulting

- Faults are cracks or fractures in rocks.
- Folding and faulting often takes place together.
- Large scale faults are associated with plate boundaries, when plates move the crust near the boundary becomes cracked and forms faults
- These faults are often at right angles to plate boundaries and are known as transform faults.

Types of faults:

Faults are caused by:

1. Compression
2. Tension
3. Lateral / strike – slip



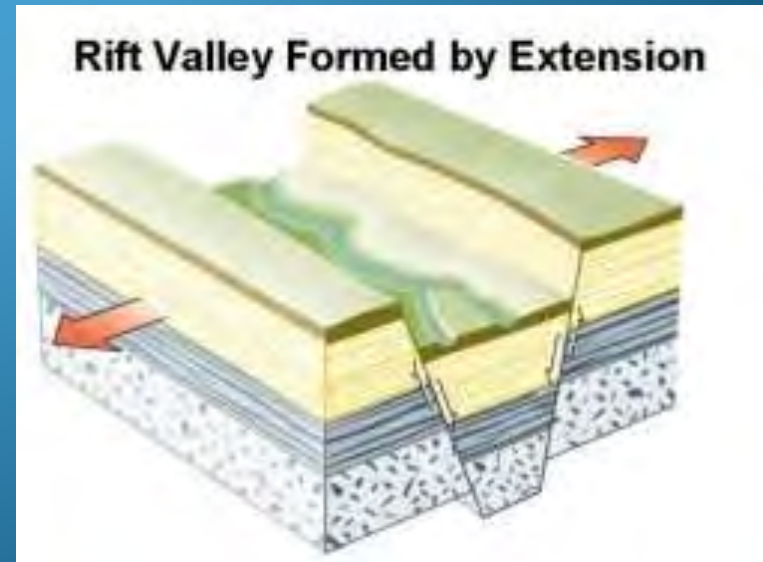


Activity 3 page 161

Landforms associated with faulting

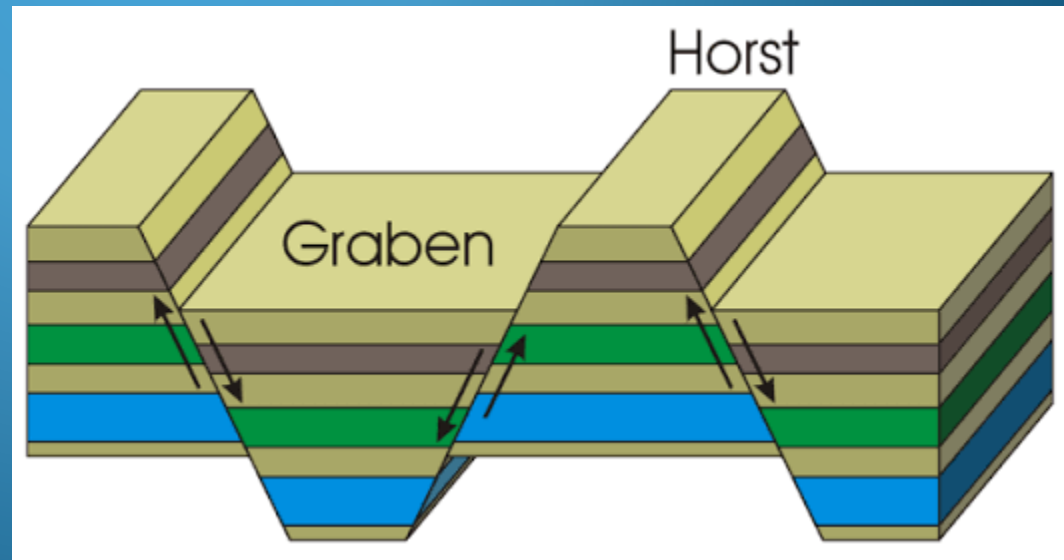
1. Rift valleys

- Convection currents in the mantle set up tension forces within the earth's crust
- These cause faults to develop
- Blocks of crust fracture and slide down the fault planes
- This process is known as rifting



2. Block mountains

- Block mountains are associated with rift valleys
- Rift valleys slip downwards along the fault plane due to divergence.
- Block mountains form from compression caused by tension
- Compression results in crust being pushed upwards to form block mountains.



Earthquakes



How & where Earthquakes occur

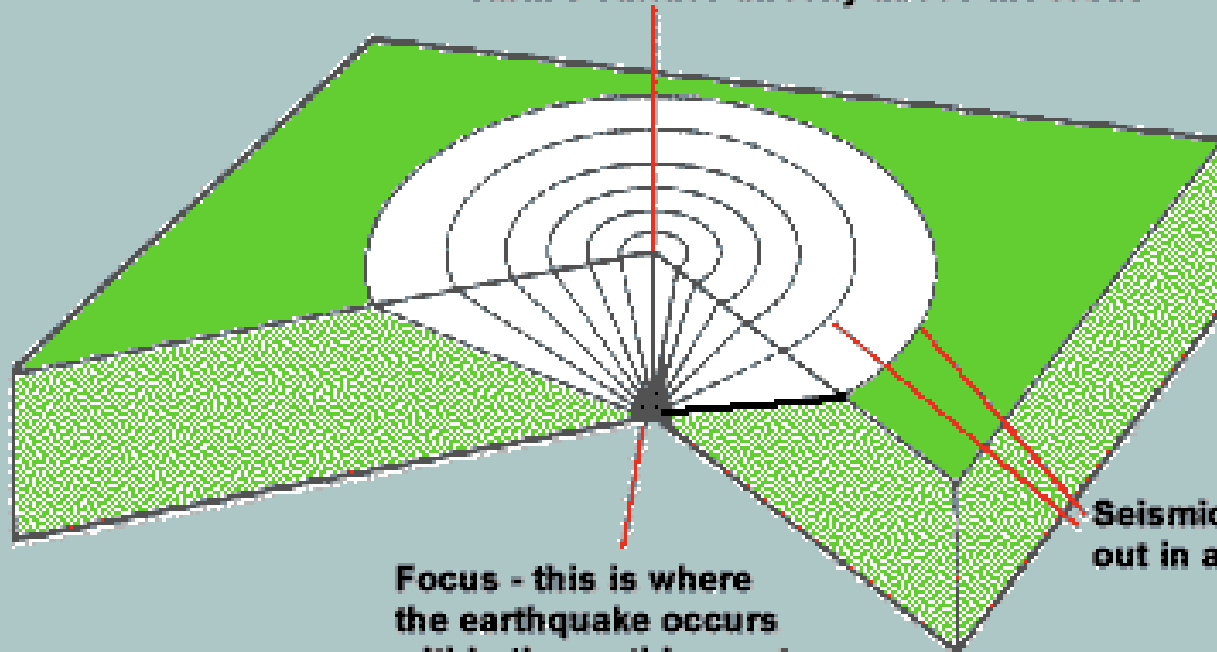
- Earthquakes are violent movements of Earth's crust, associated with plate movements.
- Most Earthquakes happen under the oceans, many go unnoticed with no damage.
- Divergent plate boundaries are the most active EQ zones
- Earthquakes can cause tsunamis, causing deaths and flooding, killing 1000's of people and damage to buildings

How they occur:

- Movement within the earth's crust causes stress to build up at points in the crust.
- When the stress is too great, a fault occurs (fracture of the rock)
- This stored energy is suddenly released as an Earthquake.
- The movement of the crust causes vibrations called *seismic waves*.
- The point at where the EQ occurs is the *focus*.
- The area directly above the focus is the *epicenter*.
- Most damage occurs at the epicenter.

Seismic Waves

Epicentre - this is the point on the earth's surface directly above the focus

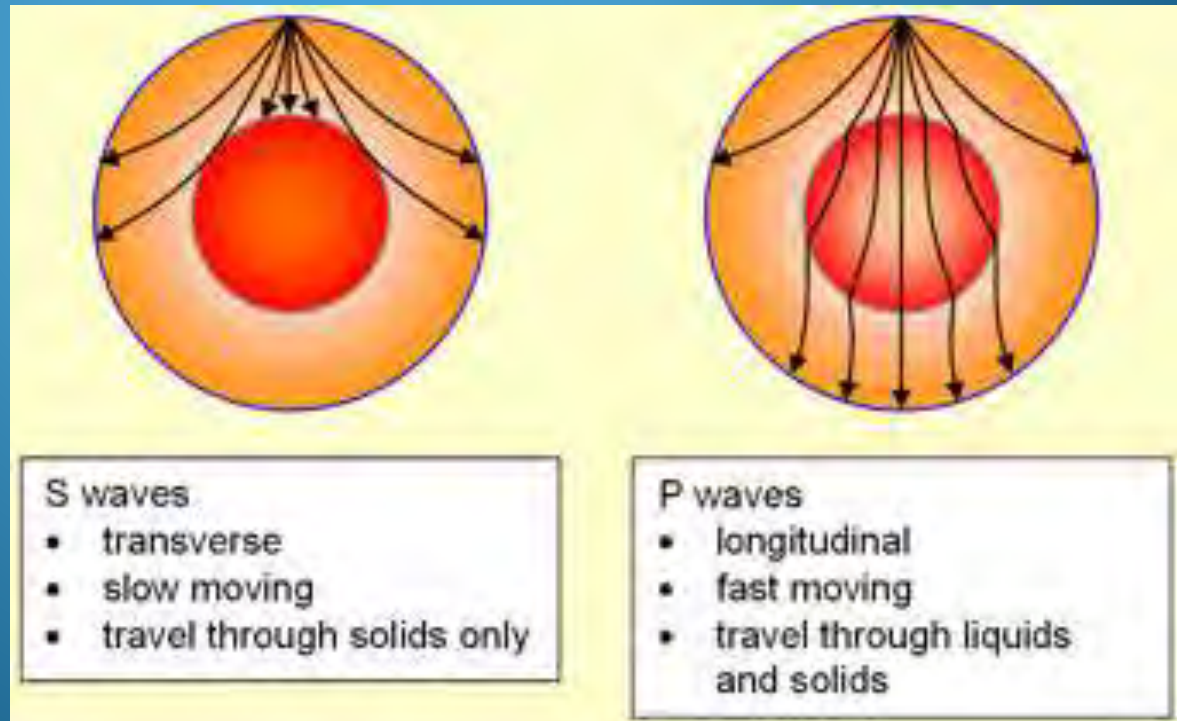


Focus - this is where the earthquake occurs within the earth's crust

Seismic waves radiate out in all directions

Seismic waves

- Seismic waves occur underground and above ground.
- P and S waves occur underground and travel from the focus through the crust toward the epicenter

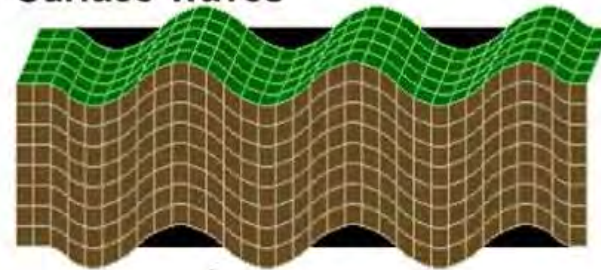


L waves occur on the surface

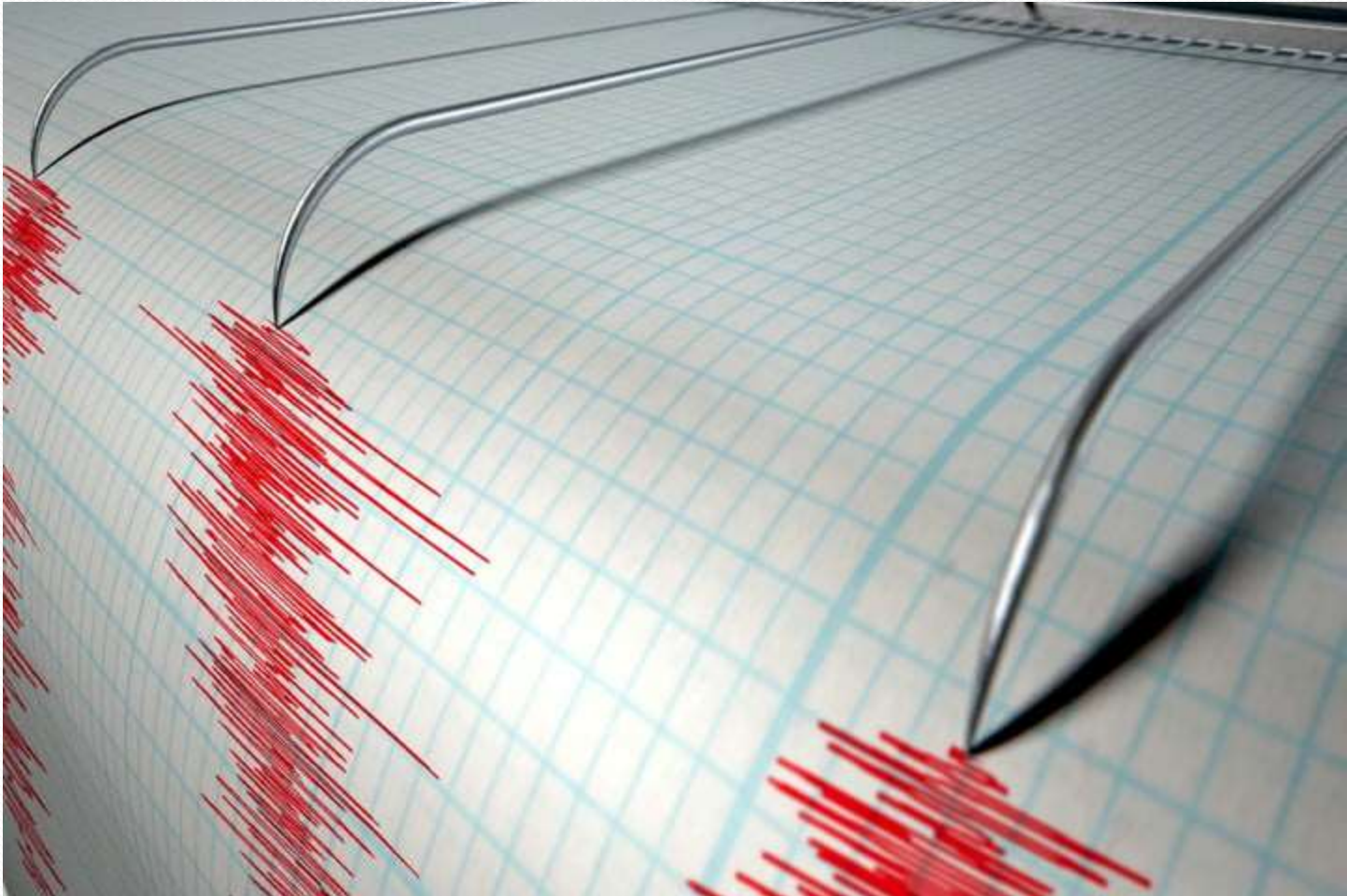
L Waves

- Surface waves cause most of the destruction resulting from earthquakes.
- **Surface waves** (L-Waves) or land waves move rock particles in a backward, rolling motion and a side-to-side, swaying motion.

Surface Waves

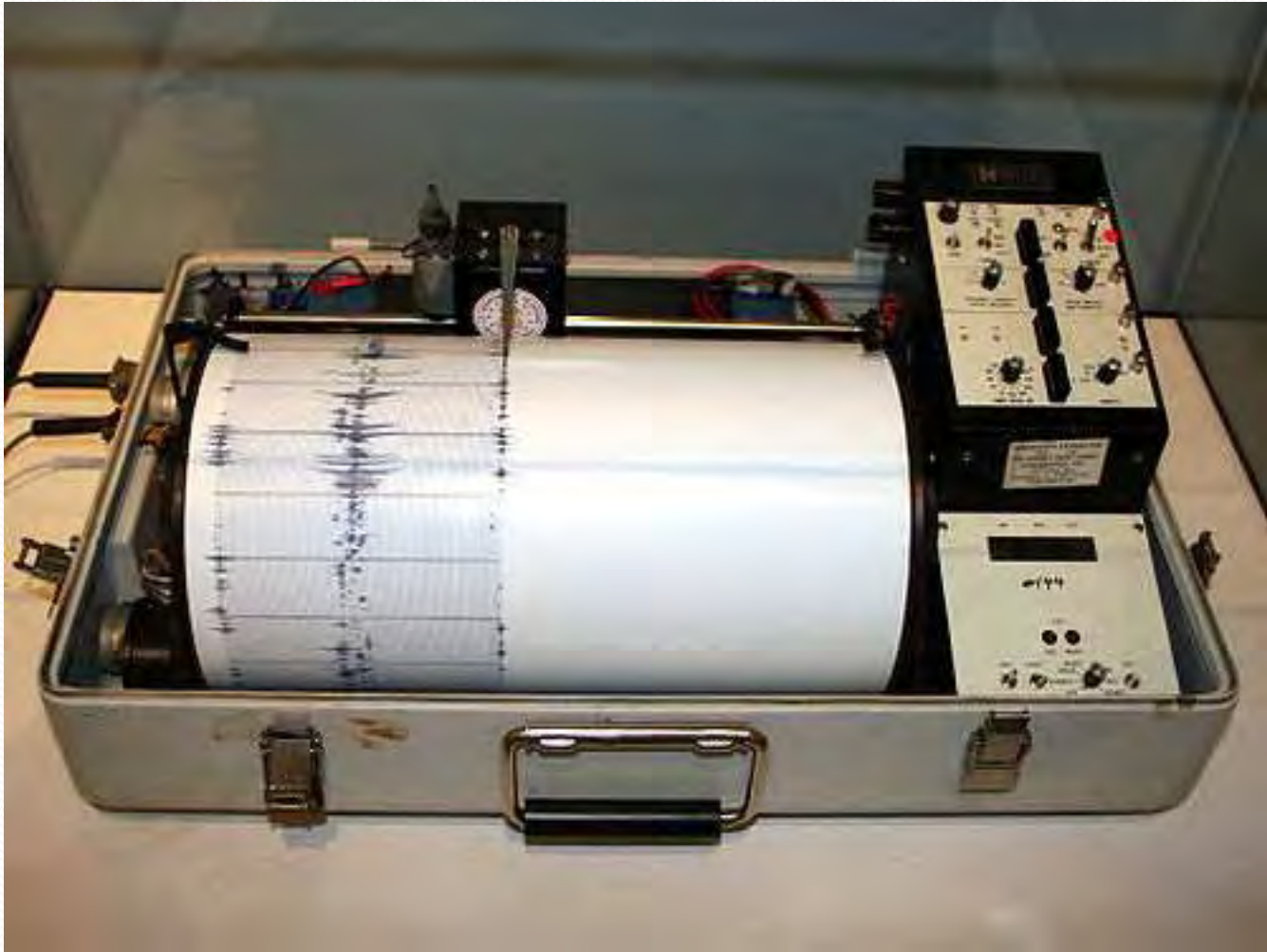


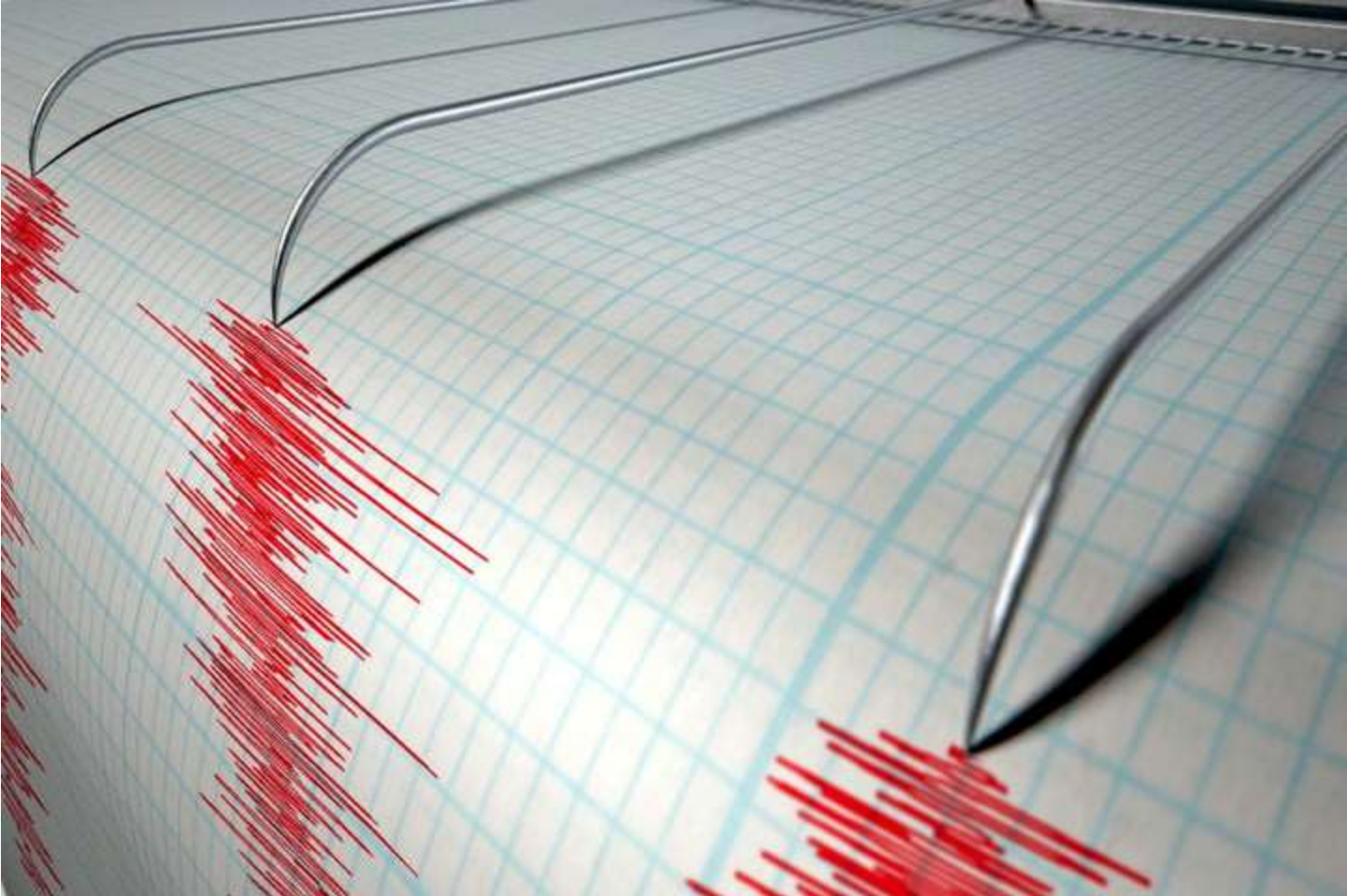
Measuring & predicting Earthquakes



1. Measuring EQ

- An instrument called a seismograph is used to measure the waves associated with earthquakes.
- Seismographs help to pinpoint location and measure the intensity.
- Wave pattern of a eq is illustrated on a seismogram.
- P waves are recorded first cause they travel the fastest, followed by S waves, these do little to no damage they like ripples in a pond.
- Its only when the P and S waves reach the surface the damage takes place caused by the L waves





The Richter Scale

- The intensity/magnitude of an earthquake is measured on the Richter scale
- Each number on the Richter scale is 10 times stronger than the number before.
- E.G. – a earthquake that measures 3 on the Richter scale is 10 times stronger than a earthquake of 2.

Permanent. An impact capable of causing global change and the future of civilization as we know it.	10
Great. A ground shaking impact that can change careers and influence the future.	9
Major. An event that is capable of causing some disruption for years to come.	8
Major. A very close encounter with ramifications for the artist, author, designer and their fans.	7
Strong. A close encounter, brushing on remarkable for the artist, author, or designer.	6
Strong. An encounter that deserves critical attention and needs to be watched.	5
Moderate. An encounter that deserves attention and may have aftershocks.	4
Moderate. An event that earns fan attention and is worth sharing.	3
Small. A movement that may or may not be routine. Hard to say.	2
Minor. Somebody felt something.	1
Unfelt. A nonevent.	0

The Liquid Hip Richter Scale



2. Predicting EQ

- People are unable to predict earthquakes accurately however they have the following ways to help with Early warning of a possible earthquake:
 - Rocks swell and cracks develop
 - Radon gas is found in soil
 - Water levels in well rise
 - Animals act strangely
 - Weak foreshocks can be recorded by seismometers

Impact of earthquakes on MEDC's & LEDC's

Refer to page 168 table 3.2

Reducing the impact of EQ's

- Early warning systems – will provide people the time needed to prepare or leave an area that is expecting a tsunami or earthquake.
- Stronger buildings – see page 171



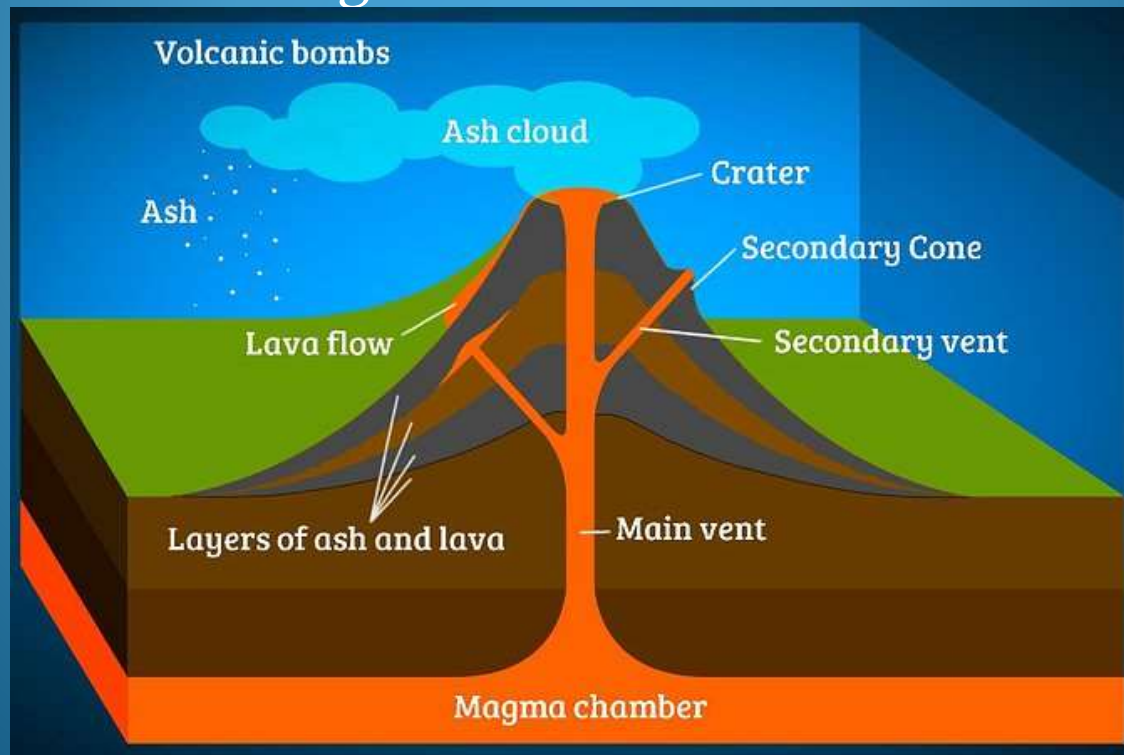
Examples of earthquakes page 172

Volcanoes



Kinds of volcanic activity

- Extrusive volcanic activity – takes place above the Earth's surface as lava
- Intrusive volcanic activity – takes place below the Earth's surface as magma



Types of volcanoes:

- Active volcano – erupts regularly about every 20 years
- Dormant volcano – has not erupted in a long time say over a hundred years.
- Extinct volcano – has no signs of erupting again and has been dormant for 100 – 1000 years

Classification of volcanoes

We classify volcanoes according to their shape and eruption.

1. Cinder cone volcano
2. Shield volcano
3. Composite volcano

1. Cinder cone volcano

- Steep cone shaped hill with a bowl-shaped crater at the summit
- The cone is made up of small rock fragments called cinders
- Cinders form from lava that contains gas bubbles.



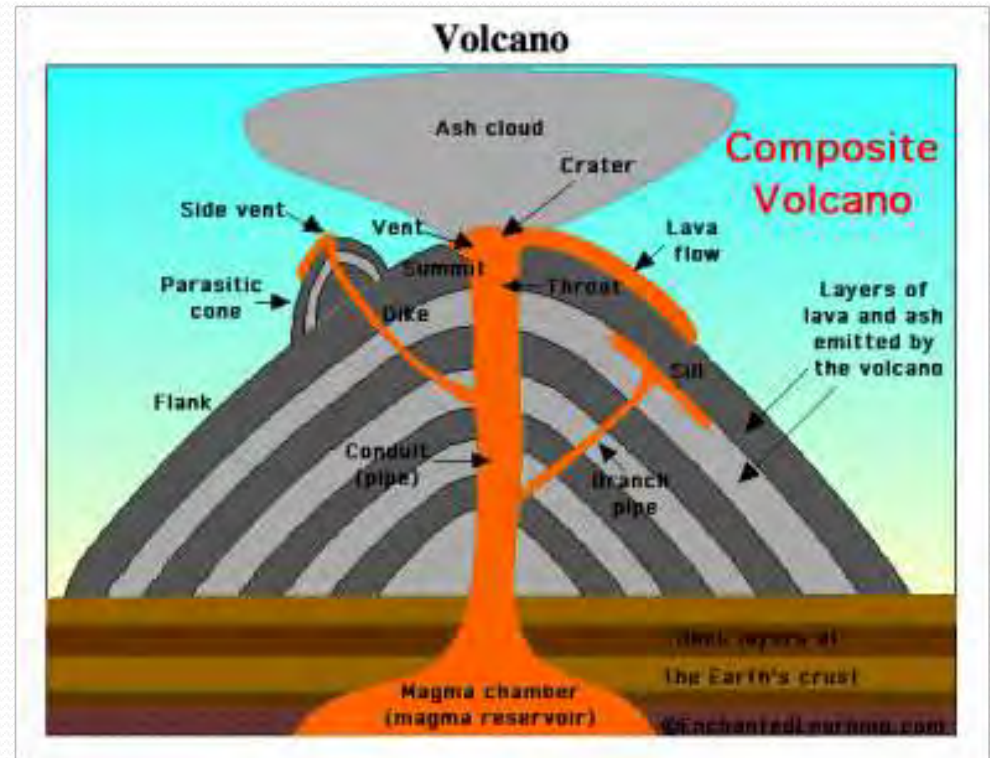
2. Shield volcano

- Cover a large area, largest of all volcanoes
- The lava can erupt from a number of vents at the same time.
- Over half the land area of India is made up of basalt that erupted from shield volcanoes

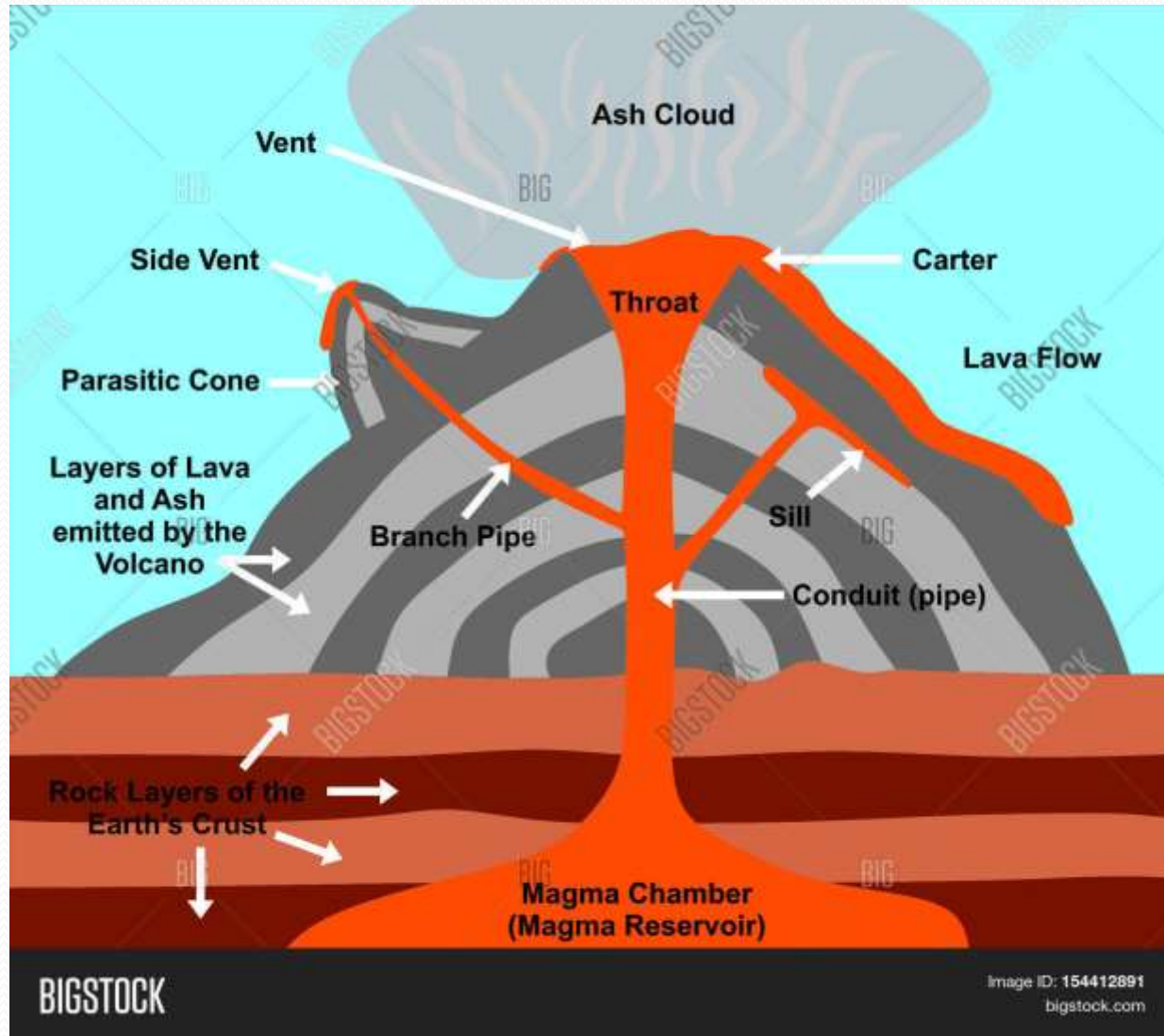


3. Composite volcano

- Made up of alternating layers of ash and lava
- The different layers relate to the different type of eruption.
- See figure 3.111



The structure of a volcano



Formation of a caldera

- Sometimes a huge eruption will empty the magma chamber and crack the cone of the volcano.
- This will result in the volcano collapsing inwards
- Over time water will collect in the caldera.



Impact of volcanoes on people & the environment

Positive effects:

- Lava weathers to form fertile soil
- Volcanic ash contains nutrients for soil
- Volcanic rock is good for building
- Hot springs attract tourists

Negative effects:

- People die
- Property destroyed
- Toxic gases cause acid rain and pollution
- Cover vegetation
- Melt snow and cause mud flows



Case studies page 180-181