EVIDENCE FOR SEA FLOOR SPREADING / DIVERGENCE OF PLATES

Pillow lavas at the mid ocean ridge indicate that magma is rising to the sea bed and forming new rock. This new basaltic rock causes slab push as it pushes the two oceanic plates apart and produces sea floor spreading. The pillow lavas have their characteristic shape due to rapid cooling in the ocean depths

The **age of the oceanic crust** increases as you move away from the mid ocean ridge. At the MOR the rocks are very young maybe even only hours old, but near the continental edge of the oceans they may be 200 million years old

The **mid ocean ridge** runs the length of the constructive plate boundaries, due to uplift by rising magma and volcanic activity There is also a positive gravity anomaly at the constructive boundary due to the mid ocean ridge

The linear **mid ocean rift valley** that forms as the two oceanic plates separate and crustal rocks subside. This rift follows the length of the diverging boundary and has features such as sheeted dykes beneath the pillow lavas

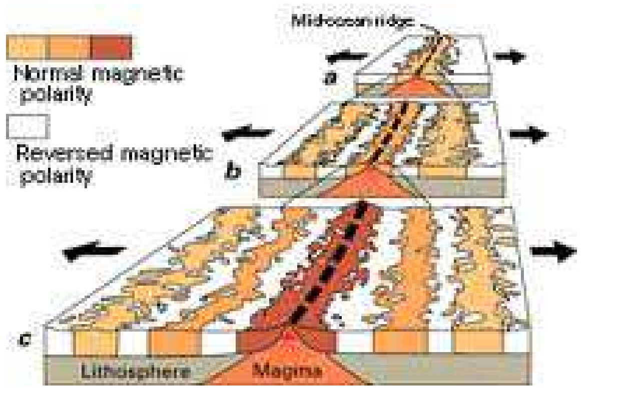
The **thickness of oceanic sediment**. This sediment comes from planktonic material that falls to the ocean floor. This is thicker away from the MOR, where there has been more time for sediments to accumulate

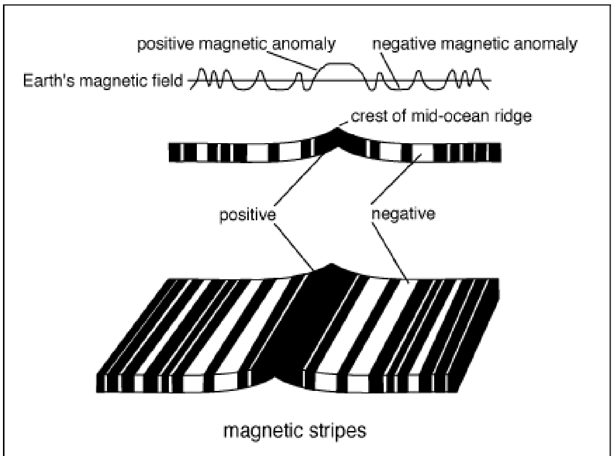
The **mid ocean ridge** is offset by a number of **transform faults** to allow for the curvature of the earth. Shallow **earthquakes** are common here and at the faults adjacent to the rift valley

Evidence from Magnetic Stripes
Rocks that make up the ocean floor lie in a pattern of magnetized stripes parallel to the diverging boundary which hold a record of the reversals in Earth's magnetic field

Heat flow is greatest at the constructive plate boundary as magma is rising to form pillow lavas and volcanoes

PALAEOMAGNETISM and MAGNETIC ANOMALY STRIPES





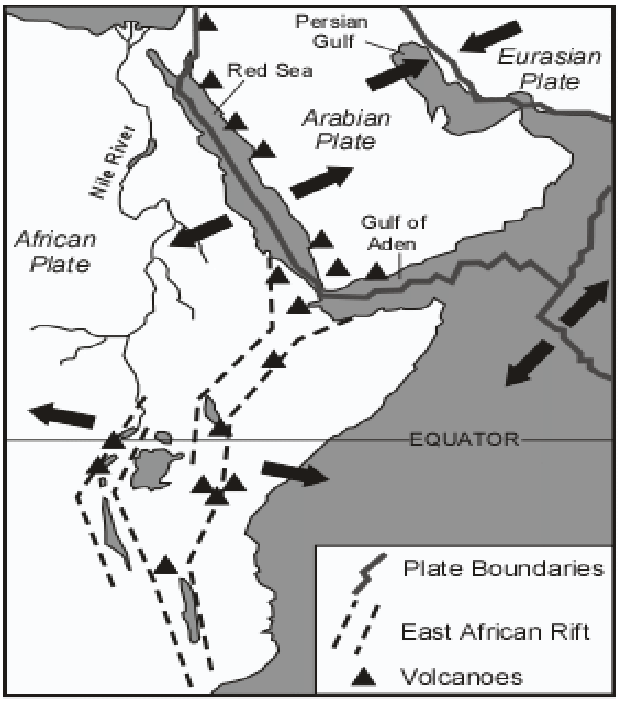
Magnetism is trapped in rocks

The Curie point -- fixing magnetism at a certain temperature
When a rock is heated above the **Curie Point**, magnetism is lost because the atoms are moving too freely. When the rock cools through the Curie Point, the atoms are frozen in a position that is aligned with the ambient magnetism. This is similar to the process of recording a magnetic tape (except THAT does not involve heat). Once the rock has been so **magnetized**, it can then be read back.

Polarity Reversals and the time scale
The fact that magnetic reversals can be recorded in the rock provides us with a powerful tool for refining the dating of rocks. This is because magnetic reversals represent global events, which provide a precise way to correlate from one place to another. Magnetic reversals have been used to correlate and refine the time scale.

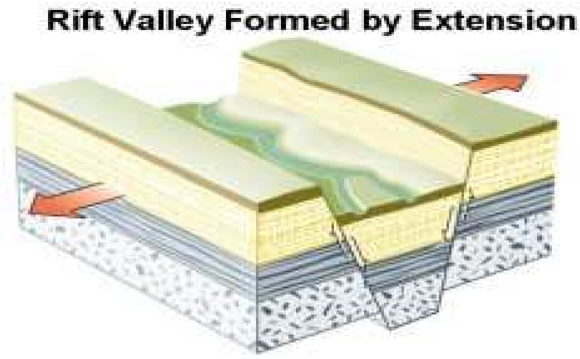
Reversals and sea-floor spreading
Since lava is more or less regularly pouring from the mid-oceanic ridges and since the oceanic floor moves away from the ridge on a conveyer belt system after it is formed, it acts something like a magnetic recording tape which keeps a record of magnetic reversals. Since the age of the reversals is known, the speed of plate movement can be precisely calculated through time.

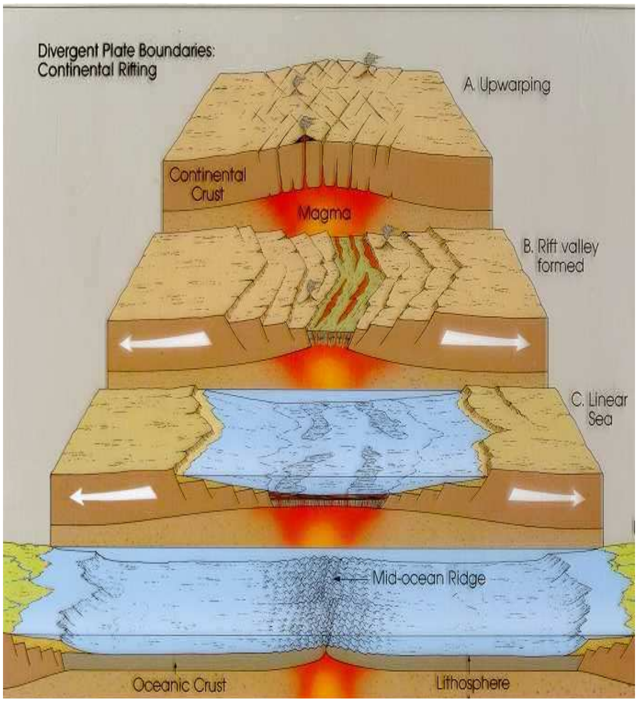
RIFT VALLEYS - DIVERGENCE ON A CONTINENT



What is a rift valley?

- It is an elongated, deep valley with two high blocks at the sides. This trough may be thousands of kilometres long. There are usually steep fault scarps at its sides. A rift valley can be caused by *compression* or *tension*.
- *Great Rift Valley* in East Africa is the longest rift valley in the world, stretching for over 4,800 km.

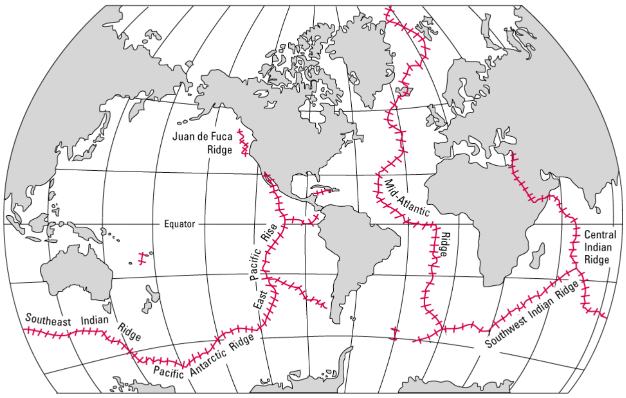




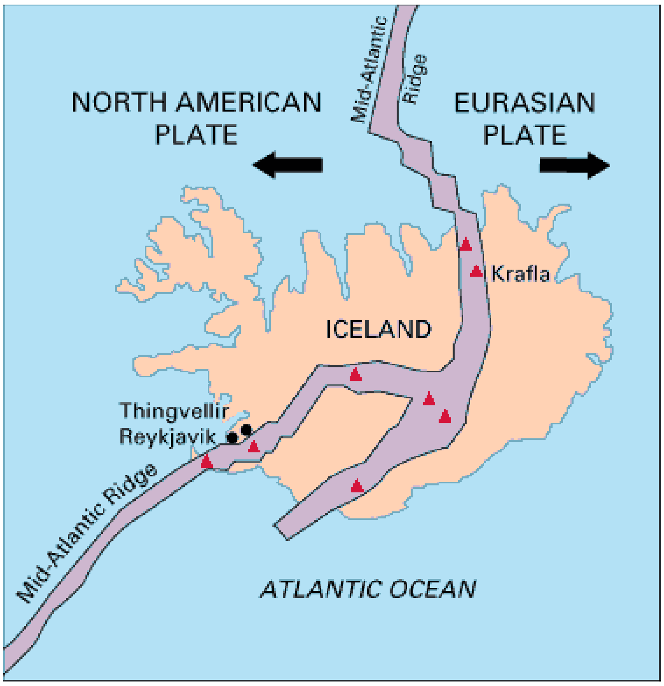
Volcanism / Vulcanism also occurs in continental areas that are undergoing episodes of extensional deformation. A classic example is the East African Rift Valley, where the African plate is being split. The extensional deformation occurs because the underlying mantle is rising from below and stretching the overlying continental crust. Upwelling mantle may melt to produce magmas, which then rise to the surface, often along normal faults produced by the extensional deformation. Basaltic and rhyolitic volcanism is common in these areas. In the same area, the crust has rifted apart along the Red Sea, and the Gulf of Aden to form new oceanic ridges. This may also be the fate of the East African Rift Valley at some time in the future.

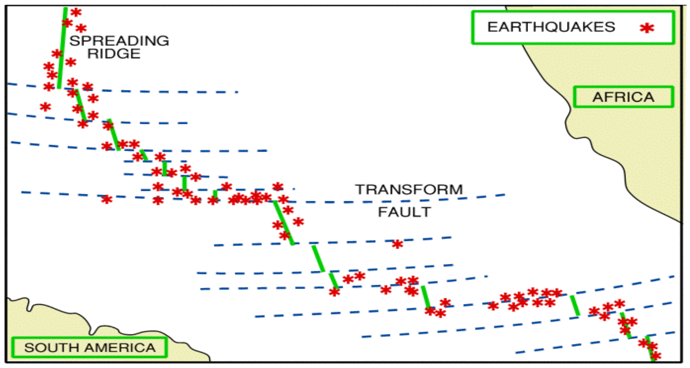
The exact mechanism of rift formation is an on-going debate among geologists and geophysicists. One popular model assumes that elevated heat flow from the mantle (strictly the asthenosphere) is causing a pair of thermal "bulges" in central Kenya and the Afar region of north-central Ethiopia. These bulges can be easily seen as elevated highlands on any topographic map of the area. As these bulges form, they stretch and fracture the outer brittle crust into a series of normal faults forming the classic horst and graben structure of rift valleys. Most current geological thinking holds that bulges are initiated by mantle plumes under the continent heating the overlying crust and causing it to expand and fracture. Ideally the dominant fractures created occur in a pattern consisting of three fractures or fracture zones radiating from a point with an angular separation of 120 degrees. The point from which the three branches radiate is called a "triple junction" and is well illustrated in the Afar region of Ethiopia where two branches are occupied by the Red Sea and Gulf of Aden, and the third rift branch runs to the south through Ethiopia.

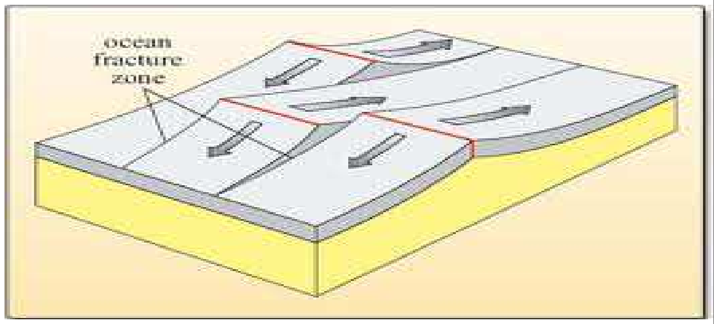
MOR - MID OCEAN RIDGE



A **mid-ocean ridge** (**MOR**) is a general term for an **underwater mountain system** that consists of various mountain ranges (chains), typically having a valley known as a **rift** running along its spine, formed by **plate tectonics**. This type of oceanic ridge is characteristic of what is known as an **oceanic spreading centre**, which is responsible for **seafloor spreading**. The uplifted seafloor results from **convection currents** which rise in the mantle as magma at a linear weakness in the **oceanic crust**, and emerge as lava, creating new crust upon cooling. A mid-ocean ridge marks the boundary between two **tectonic plates**, and consequently is termed a **divergent plate boundary**.



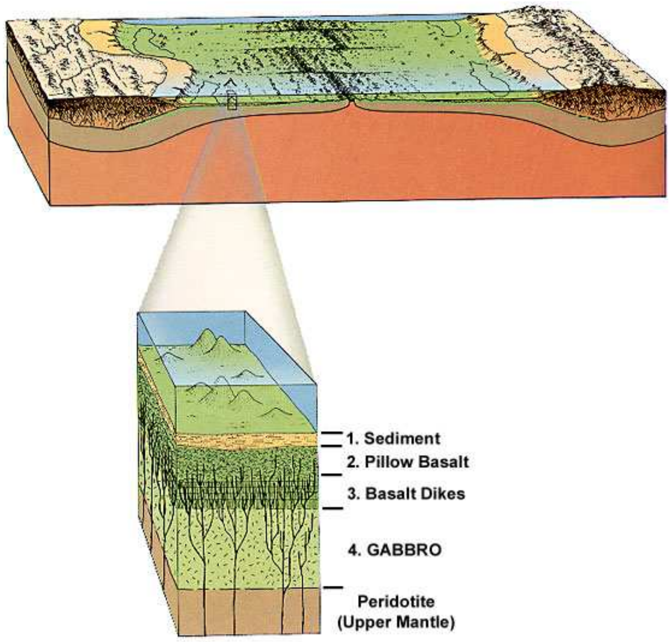




At the mid ocean ridge or sea floor spreading zone new crustal rocks are created and the oceanic crust typically has the following structure:-

1. **Ocean sediment** produced by planktonic material in the sea dying and falling to the sea bed, this gets thicker away from the MOR
2. A layer of **pillow lavas** formed when lava is erupted onto the sea floor and is cooled very rapidly to leave pillow shapes
3. Thin sheets of basalt forming **'sheeted dikes'** caused by each new pulse of lava pushing up and forcing the two plates apart
4. A zone of basic plutonic igneous rock, **Gabbro**, that corresponds to the feeding magma chamber
5. Beneath this is the upper mantle rock this generally is ultra basic **Peridotite**

Occasionally this sequence is forced up onto a continental area at the end of sea floor spreading to give an **Ophiolite**



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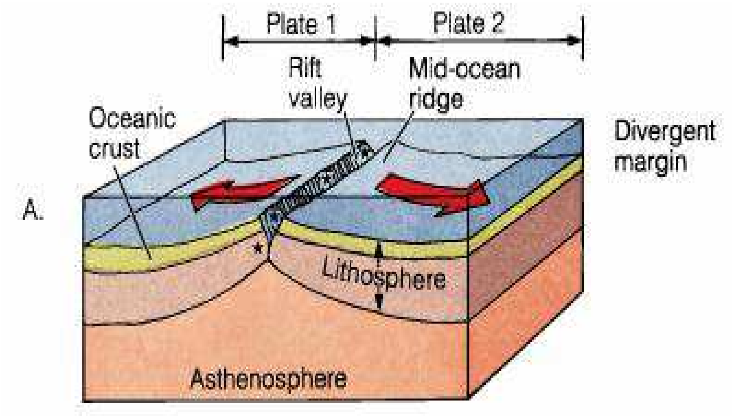
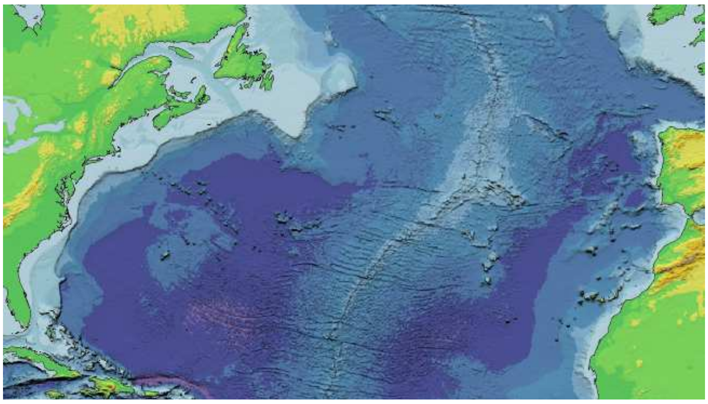
CASE STUDY REVISION BOOKLET

PLATE TECTONICS Constructive / Diverging boundaries - sea floor spreading





FACTFILE :-

1. Divergent plate boundaries are zones where lithospheric plates move apart from one another. They are characterized by tensional stresses that typically produce long rift zones, normal faults, and basaltic volcanism.

2. An oceanic ridge marks divergent plate boundaries in the ocean basins. It is a broad fractured swell with a total length of about 70,000 km. Basaltic volcanism and earthquakes are concentrated along the rift zone at the ridge crest.

3. The ridge is broken into segments and its characteristics depend upon the rate of spreading.

4. Oceanic crust is generated at divergent plate boundaries and is composed of four major layers: (a) deep marine sediment, (b) pillow basalts, (c) sheeted dikes, and (d) gabbro. Below the crust lies a zone of sheared peridotite in the upper mantle.

- Divergent boundaries occur along spreading centres where plates are moving apart and new crust is created by magma pushing up from the mantle. Picture two giant conveyor belts, facing each other but slowly moving in opposite directions as they transport newly formed oceanic crust away from the ridge crest.
- Perhaps the best known of the divergent boundaries is the Mid-Atlantic Ridge. This submerged mountain range, which extends from the Arctic Ocean to beyond the southern tip of Africa, is but one segment of the global mid-ocean ridge system that encircles the Earth. The rate of spreading along the Mid-Atlantic Ridge averages about 2.5 centimetres per year (cm/yr), or 25 km in a million years. This rate may seem slow by human standards, but because this process has been going on for millions of years, it has resulted in plate movement of thousands of kilometres. Seafloor spreading over the past 100 to 200 million years has caused the Atlantic Ocean to grow from a tiny inlet of water between the continents of Europe, Africa, and the Americas into the vast ocean that exists today.