Subject
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First year
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Lecturer

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1. Introduction

Geology is the study of the Earth, including the materials that it is made of the physical and chemical changes that occur on its surface and in its interior, and the history of the planet and its life forms.

Geology is an Arabized word from the Greek term Geology, in which the syllable Geo refers to "geo", meaning earth, while the syllable logy refers to "logia", meaning science.

The Earth is a planet or body that is almost perfectly round, with a slight flattening at the poles and a dent at the equator. It is one of the bodies that revolve around the sun in the same direction and in almost the same plane with the group of nine planets. The Earth occupies an intermediate position among the planets in many ways. For example, it is the largest. Small planets in size. It is 93,000,000 miles away from the sun. The specific density of the earth is about 5.5. The Earth's polar diameter is about 7,900 miles (12,650 km.) and the equatorial diameter is 7,927 miles. So, it is oblate spheroid. The Earth's circumference is about 24,874 miles, 29% of the Earth's surface area is land and 71% is covered by water.

2. Earth rotation

Earth's rotation or Earth's spin is the rotation of planet Earth around its own axis, as well as changes in the orientation of the rotation axis in space. Earth rotates eastward, in prograde motion. As viewed from the northern polar star Polaris, Earth turns counterclockwise.

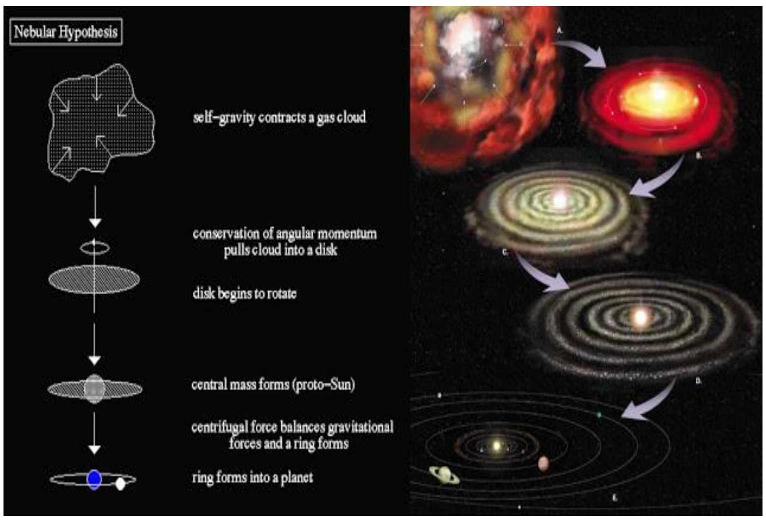
Earth rotates once in about 24 hours with respect to the Sun, but once every 23 hours, 56 minutes, and 4 seconds with respect to other distant stars. Earth's rotation is slowing slightly with time; thus, a day was shorter in the past. This is due to the tidal effects the Moon has on Earth's rotation. Atomic clocks show that the modern day is longer by about 1.7 milliseconds than a century ago, slowly increasing the rate at which UTC is adjusted by leap seconds. Analysis of historical astronomical records shows a slowing trend; the length of a day increased by about 2.3 milliseconds per century since the 8th century.

3. Origin and age of the earth

There are several Hypothesis have been discussed the origin of the earth, but these hypotheses are not totally accepted.

A- Nebular hypothesis

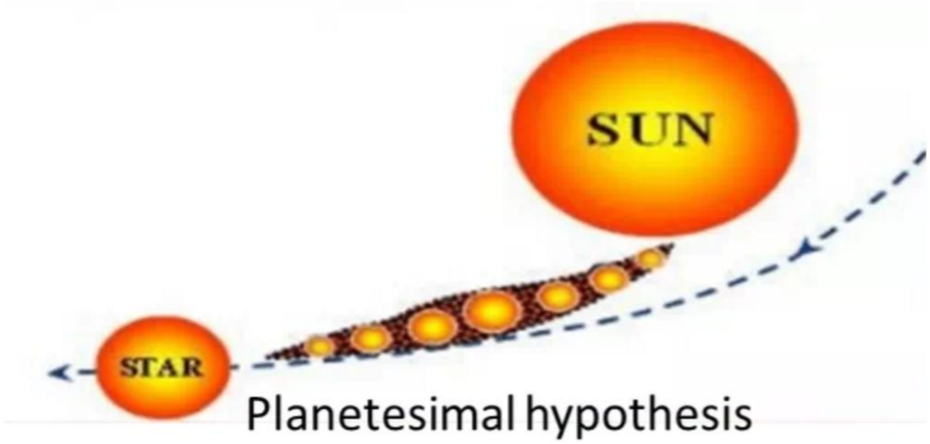
- The theory was developed by Immanuel Kant (1755) and then modified in 1796 by Pierre Laplace
- It suggests the Solar System is formed from gas and dust orbiting the sun which clumped up together to form the planets.
- According to the nebular theory, stars form in massive and dense clouds of molecular hydrogen-giant molecular clouds. These clouds are gravitationally unstable, and matter coalesces within them to smaller denser clumps, which then rotate, collapse, and form stars.
- The most important objection to it is the mechanism of separation of the nebula rings, which is impossible because the speed of the sun's rotation is very slow compared to the speed of the planets' rotation.



Nebular hypothesis

B- Planetesimal Hypothesis

- It was proposed by Forrest R. Moulton and Thomas C. Chamberlin about 1900.
- The theory states that the planets were formed by the accumulation of extremely small bits of matter planetesimals that revolved around the sun.
- During the near-collision, hot gases were pulled out of both stars and the gases then condensed. The planetesimal hypothesis was widely accepted for about 35 years.
- The greatest flaw in the theory is the assumption that the material drawn out of the stars would condense. The extremely hot gases that make up a star are held together by the gravitational forces within the star. Once the material was pulled away to where the gravitational forces were weaker, it would expand because of its heat. Before condensation could take place, the gases would have almost entirely dissipated. The planetesimal hypothesis is no longer considered a likely explanation of the origin of the solar system.

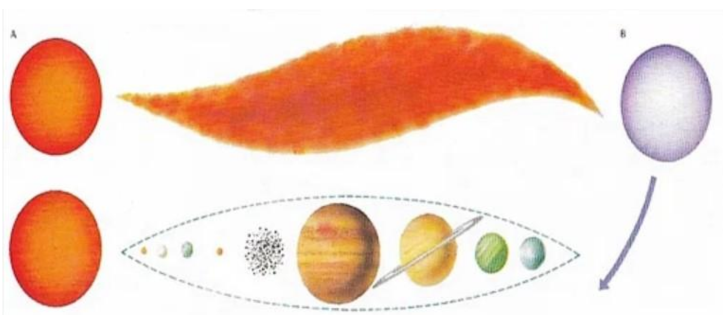


Planetesimal Hypothesis

C- Tidal or Gaseous Hypothesis

- Sir James Jeans, proposed his 'tidal hypothesis' to explain the origin of the earth in 1919, while Harold Jeffreys, suggested modifications to the 'tidal hypothesis' in 1929
- They accept the idea of the sun, and another invading star formed the solar system.
- The sun was stationary and rotated on its axis. The ‘intruding star’ was moving along a path in such a way that it was destined to come nearer to the primitive sun. The intruding star's tidal force had a significant impact on the surface of the primitive sun. According to James Jeans, a massive amount of matter was ejected from the primitive sun because of the intruding star's massive gravitational force, which later became the building material for future planets.

- Everyone in the universe attracts every other body with a force that is directly proportional to the product of the two bodies' masses and inversely proportional to the square of the distance between them, according to Newton's law of universal gravitation.
- Astronomers believe that the filaments are gases. They cannot be solid bodies like our planets because these filaments would vanish It disappears in space. For these reasons, this hypothesis was not accepted for long.



Tidal hypothesis

4. Classification of geology science

Geology is a broad field with a variety of branches. According to traditional classifications, there are two main areas of geology:

physical geology and historical geology. Besides, environmental geology is also a major area that is recently developed.

Physical geology This branch deals with the study of Earth's materials, including minerals and rocks, and the processes that shape and modify the Earth's surface, such as weathering, erosion, plate tectonics, and volcanic activity.

Historical geology, which is also referred to as paleogeology, is a major discipline that focuses on the history of geosocial processes. The main goal of the discipline is to reconstruct the geological history of Earth based on various geological methods.

Branches

Structural Geology, Structural geologists study the deformation of rocks and geological structures like faults and folds, seeking to understand the forces that cause these deformations and the implications for Earth's crust.

Mineralogy, Mineralogy is the study of minerals, their properties, crystal structures, and occurrences in nature. Mineralogists identify and classify minerals based on their physical and chemical characteristics.

Stratigraphy, Stratigraphy involves the study of rock layers (strata) and their chronological sequence, helping to establish a relative and absolute timeline of Earth's history.

Geophysics, Geophysics applies physics principles to study Earth's interior and its physical properties, including seismicity , gravity, magnetic fields, and electrical conductivity.

Volcanology, Volcanology is the study of volcanoes , volcanic processes, and volcanic landforms. It involves understanding volcanic eruptions, magma composition, and volcanic hazards.

Paleontology, Paleontology deals with the study of past life through fossils, helping to reconstruct the history and evolution of life on Earth.

Sedimentology, Sedimentology is the study of sedimentary rocks and the processes involved in their formation, including deposition, transportation, and diagenesis. It often provides insights into past environments and Earth's history.

Hydrogeology, Hydrogeologists study the distribution and movement of groundwater in the subsurface and its interaction with geological formations.

Engineering Geology, Engineering geologists apply geological principles to civil engineering projects, assessing geological hazards and ensuring the stability of structures.

Petrology, Petrology focuses on the study of rocks, their origin, formation, classification, and the processes that lead to their transformation from one type to another.

Geochemistry, Geochemistry examines the distribution and behavior of elements and isotopes within the Earth's crust and how these impact geological processes

Geomorphology, Geomorphologists investigate the landforms and landscapes on Earth's surface, studying how they are shaped by geological processes such as erosion, weathering, and tectonics.

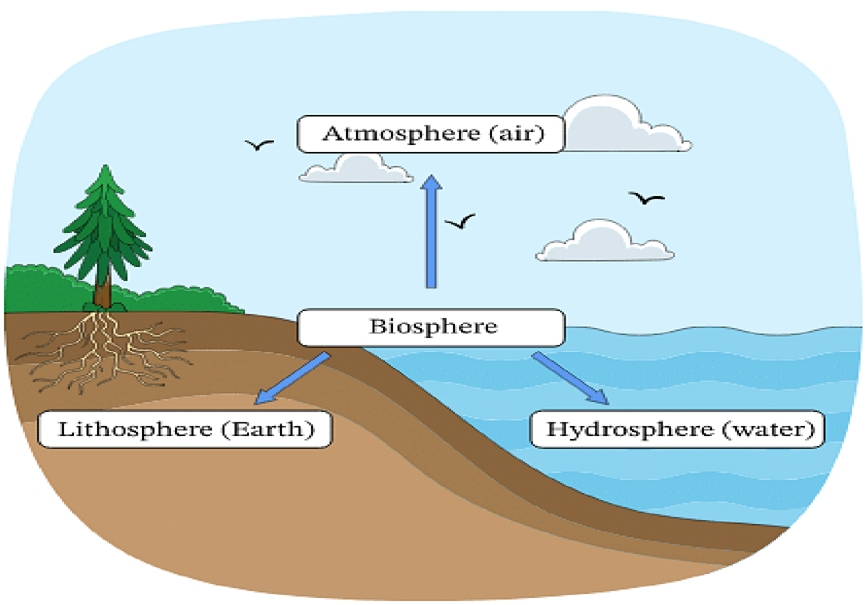
Important of geology

- Searching for energy sources such as petroleum.
- Searching and prospecting for various mineral ores such as gold.
- Exploring groundwater reservoirs as a source of irrigation and drinking.

- Determine the suitability of selected sites for constructing giant engineering projects such as bridges.
- producing building and construction materials such as sand
- Contributing to protecting the environment.
- Reducing environmental and geological risks, such as risks resulting from volcanoes.

5. Principle divisions of earth (earth shells)

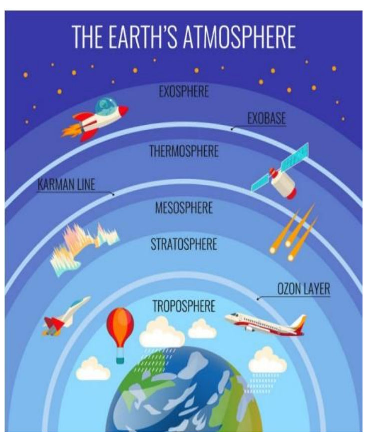
There are four domains for the earth, atmosphere, hydrosphere, biosphere, and lithosphere



Earth shells

Atmosphere

- This domain surrounds the earth.
- Composed of gas, dust, microorganisms
- Dry air contains 78% nitrogen, 21% oxygen, 0.03% carbon dioxide, 0.93% argon , in addition to helium, hydrogen, neon , crypton, ozone,….
- Natural air is not dry, and always contains varying amounts of water vapor.
- From a geological view the air contains oxygen, co2, and vapor.
- The atmosphere extended to 200 miles over the see
- The atmosphere is classified into five layers,



- The change in temperature from place to place is due to the winds found in the troposphere. The change in temperature causes the rocks to crack and crumble, and we find that the wind (which is moving air) cools and moves the fragmented rocks and creates waves and currents in the ocean waters. During weathering factors, the air interacts chemically with the rocks, forming new compounds. The atmosphere plays a major role in the occurrence of rain and hail, as well as its role in the transmission of sunlight through reflections on dust grains suspended in the air, and in protecting the Earth from the dangers of meteors and meteors that disintegrate before reaching us because of prolonged contact with the air.

Hydrosphere

- Represents all-natural water, such as the water of seas, oceans, rivers, lakes, and ponds, as well as the groundwater in which the earth's rocks are absorbed.
- Covers 71 % of the earth, if we imagine the earth surface has become paved and flat so the water of hydrosphere cover it reaches about 2 mile or 3.2 km.
- The ocean is not only full of water, as we find that 2% of its volume consists of nitrogen, oxygen, and some other dissolved gases, as well as 3% of the weight of its water are

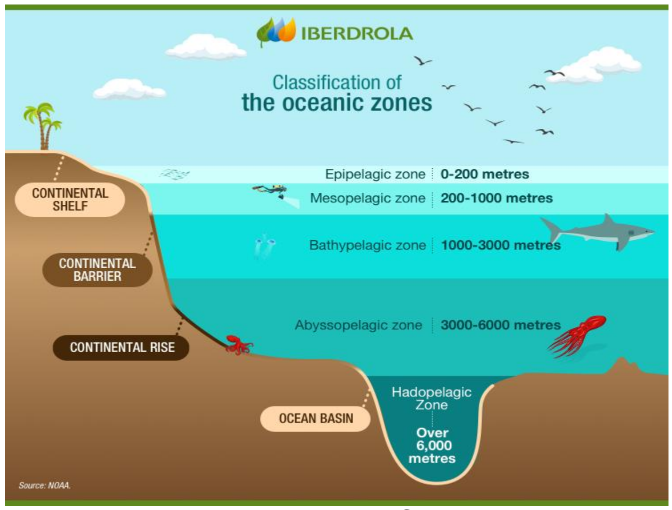
salts consisting mainly of sodium chloride, which is dissolved from the rocks of the solid surface of the Earth. Other components of ocean water are living organisms and suspended sediments.

- The mechanical effect of the hydrosphere on the lithosphere is due to the complex system of water flow caused by temperature irregularities, as well as currents caused by winds, differences in salinity, etc. Rivers and tributaries carry countless quantities of crumbled rocks every year to the oceans, seas, and lakes, where these sediments are deposited with the remains of living organisms and are embodied in the form of sedimentary rocks of various types. Most of the sedimentary rocks that we see now above the surface of the sea, and which we recognize because they contain fossils of marine organisms, were deposited under the surface of the sea, and this sea receded from them, or they appeared above its surface, and they froze, solidified, and appeared in the form they are in now.

Lithosphere

- The solid portion of the earth
- It is composed of rocks of the earth (Sedimentary, Igneous and Metamorphic rocks).
- rock is any naturally occurring solid mass or aggregate of minerals or mineraloid matter. It is categorized by the minerals included, its chemical composition, and the way in which it is formed.
- The term mineral refers to an inorganic naturally occurring solid material, which has a specific "not fixed" chemical composition and unique crystal structure (e.g., quartz, hematite, and calcite).
- It is known that the diameter of the Earth reaches 8,000 miles in a month, and the surface of this rocky event is unusual. We find that the height of the highest peak of Mount Everest in the Himalayas is known to be 8,840 meters above sea level, and the maximum depth of the ocean is found in the Philippine Trench in the Pacific Ocean and reaches 10,800 meters. The thickness of this lithosphere is about 2900 km at the equator.

- This cover is divided into several levels or friezes Continental platform – oceanic platform – continental shelf- conventional barrier – ocean basin.

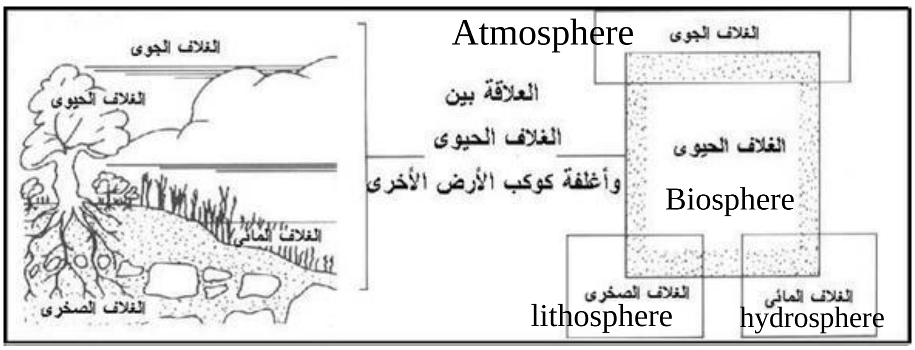


Lithosphere friezes

Biosphere

- The domain in which living organisms live, whether they are humans, animals or plants.
- This cover includes most of the hydrosphere, atmosphere, and a small part of the lithosphere, in which living organisms are found. The importance of this shell or domain is limited to the biological effects and interactions carried out by living organisms on the Earth's crust.
- This atmosphere is considered the locus of organic life on Earth. It is one of the factors influencing the various transformations and changes that occur in the parts of the

Earth near the surface. Living organisms destroy and change rocks and minerals that were previously formed, thereby giving new compounds and minerals. In addition, these organisms are considered the basic material in the formation of organic rocks such as limestone, chalk, and coal.



6. Earth structure

- Geophysical and seismic studies have shown that the internal structure of the Earth, which is located at its center at a depth of 6371 km, consists of three basic layers: the crust, the mantle, and the core.
- These layers play an important role in the passage and reflection of seismic waves due to the difference in rock density and difference in mineral composition, in addition to the difference in temperature and pressure with increasing depth. To understand internal-external processes,

theories of plate tectonics, etc., we must know the Earth structure.

<u>Crust</u>

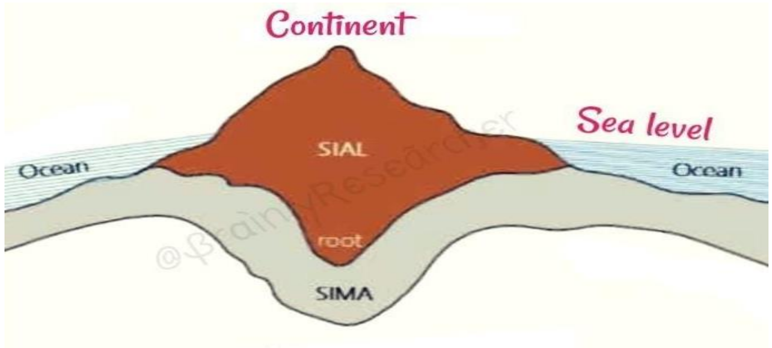
- The outer solid part of the earth
- 95% igneous and metamorphic rocks- 5% sedimentary rocks
- The rocks characterized by inhomogeneity and low density
- Varies in the thickness according to nature of land so it is divided in to

<u>Continental crust</u>

- 25-75 km thickness- granite rocks (silicates aluminum and sodium potassium)
- The density is about 2.7 gm/cm3 – termed as SIAL

<u>Oceanic crust</u>

- 5-10 km thickness- basaltic rocks (silicates magnesium and iron)
- The density is about 2.7 gm/cm3 – termed as SIAL.



Mantel

It is located under the Earth's crust - its depth reaches 2900 km from the Earth's surface - it is 60% of the Earth's mass - 84% of its volume - composed of high-density solid rocks ranging between 5-8 g/cm3 - composed of mainly iron and magnesium silicates in addition to oxygen and aluminum - the mantle is divided into.

Upper mantel

- It consists of hard, ductile rocks, most of which are olivine, pyroxene, and other minerals that crystallize at high temperatures.
- The rocks of the upper part of the mantle are characterized in a semi-liquid state in an area called the asthenosphere because of the high temperature due to the presence of radioactive minerals and are considered a source of basalt rocks.

- Due to the great pressure on it, its rocks have become in a viscous, heavy state, and the tectonic plates that carry continents and oceans over them slide, causing what is called continental drift, which is one of the main causes of earthquakes in the world.

Lower mantel

- It constitutes approximately half of the Earth's mass and is likely composed of silicon, magnesium, and oxygen, with quantities of iron, calcium, and aluminum, and it is in a solid state.

Core

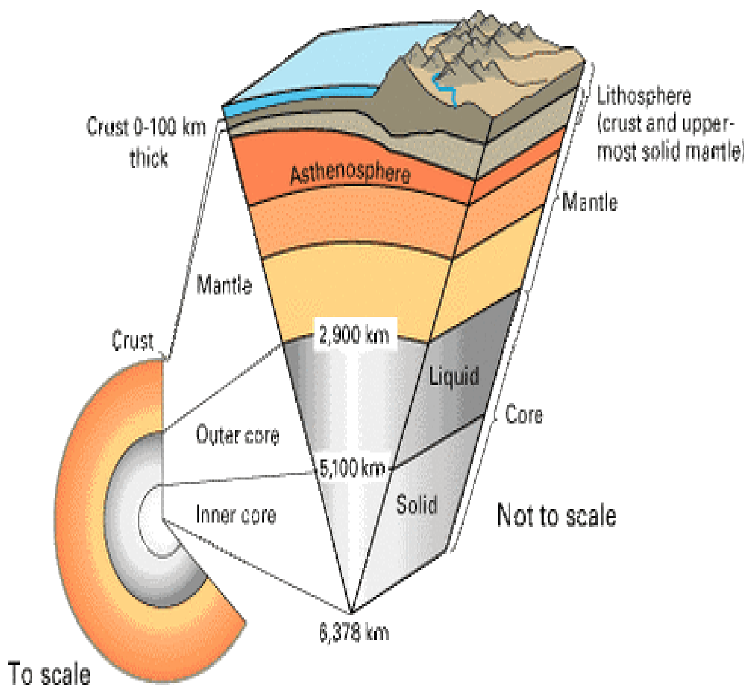
- This layer represents the central mass of the Earth and consists of iron and nickel metals. Its thickness is about 3470 km and is divided into:

Outer core

- Its thickness is 2200 km - It reaches a depth of 5100 km from the surface - It consists of iron and nickel in the liquid state - Shear waves do not propagate in it during earthquakes - Its density is 10 g/cm^3

Inner core

- It starts from a depth of 5100 km up to a depth of 6371 km, so its thickness is about 1270 km. It consists of iron and nickel in the solid state because of the enormous pressure above it, and its density ranges from 14.5 to 18 g/cm^3.



Earth structure

7. Isostatic theory

It states that at a great depth inside the Earth, known as compensation depth, an equilibrium occurs for the different parts of the crust in terms of pressures and densities, despite their differences in thickness and density.

In the theory of isostasy, a mass above sea level is supported below sea level, and there is thus a certain depth at which the total weight per unit area is equal all around the Earth; this is known as the depth of compensation. The depth of compensation was taken to be 113 km (70 miles) according to the Hayford-Bowie concept, named for American geodesists john Fillmore and William bowie. Owing to changing tectonic environments, however, perfect isostasy is approached but rarely attained, and some regions, such as oceanic trenches and high plateaus, are not isostatically compensated.

There are two different hypothesis of the equilibrium theory, suggested by scientists Airy and Pratt in the mid-nineteenth century.

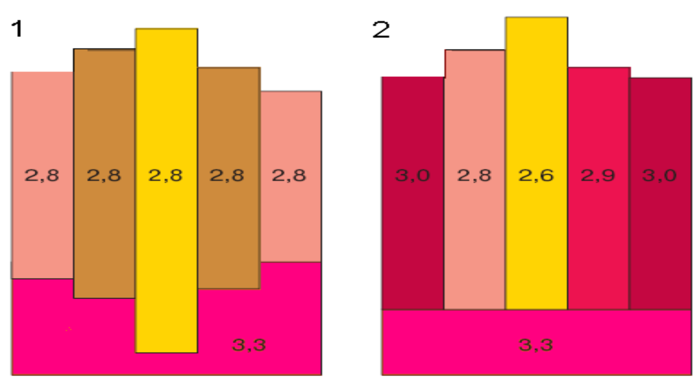
Airy hypothesis

- The Airy hypothesis says that Earth's crust is a more rigid shell floating on a more liquid substratum of greater density. He assumed that the crust has a uniform density throughout.
- The thickness of the crustal layer is not uniform, however, and so this theory supposes that the thicker parts of the

crust sink deeper into the substratum, while the thinner parts are buoyed up by it. According to this, mountains have roots below the surface that are much larger than their surface expression.

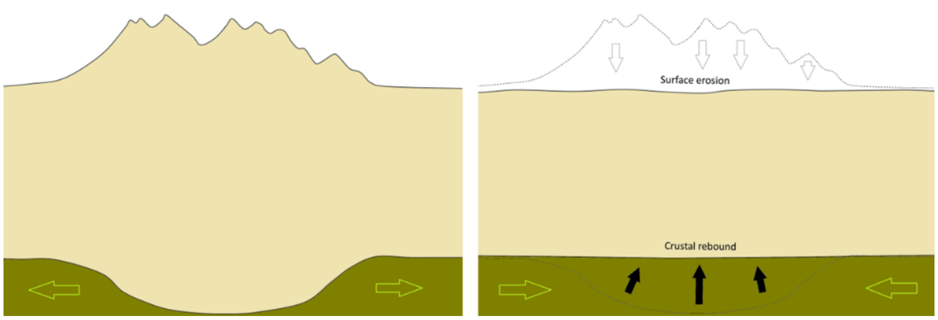
Bratt hypothesis

- Supposes that Earth's crust has a uniform thickness below sea level with its base everywhere supporting an equal weight per unit area at a depth of compensation. In essence, this says that areas of the Earth of lesser density, such as mountain ranges, project higher above sea level than do those of greater density. The explanation for this was that the mountains resulted from the upward expansion of locally heated crustal material, which had a larger volume but a lower density after it had cooled.



Airy and Bratt isostasy hypotheses

The theory of Isostasy assumes that land masses are stable and balanced despite protruding protrusions such as mountains and depths such as oceans. Therefore, we find that when sculpting occurs on the continents and their deposition in the ocean, the ocean floor sinks down due to the weight of the sedimentary fragments collected on it. This causes displacement of the rocks under the crust, causing the continents to push upward. This is what is called Static balance dimension. This type of ground movement is what results in a change in the position of the oceans and continents in the geological crisis. An example of this is the large Egyptian deserts, which were covered with seawater for varying distances in past geological times because of the sea advancing and receding from it several times.



Earth isostasy

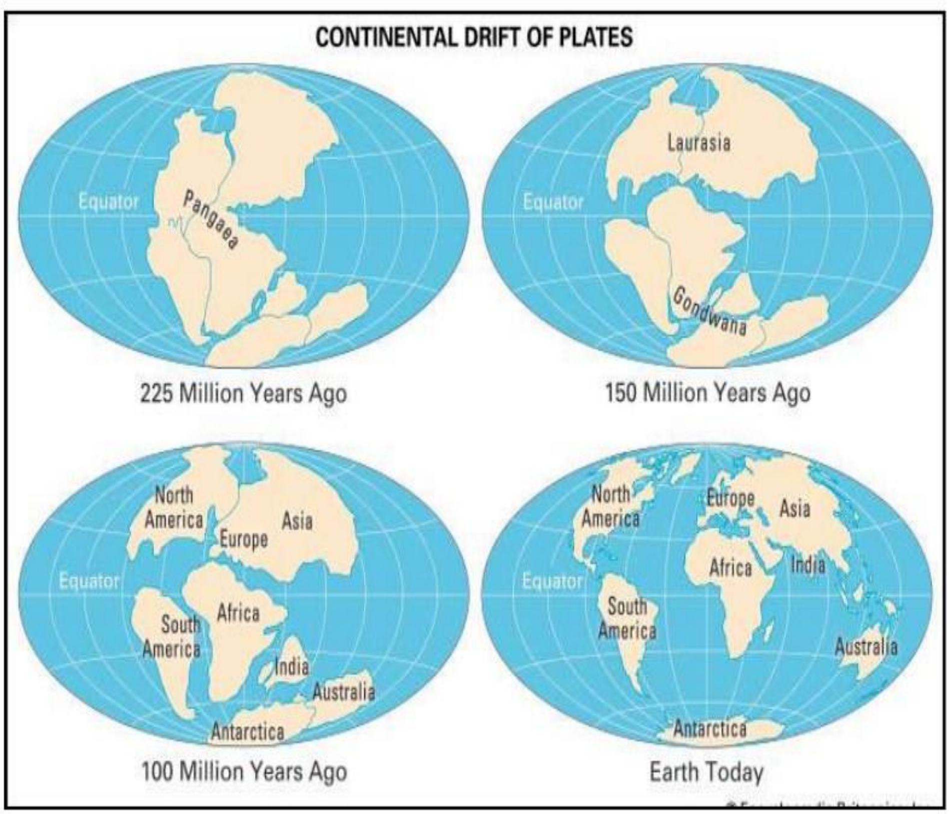
8. Continental drift

Geologists assumed that the continents existed and were fixed in place at an earlier time, but in 1620 Sir Francis Bacon noted that there was a similarity to the shores of Africa and South America overlooking the Atlantic Ocean. More than two hundred years later, Antonio Snyder noticed a similarity between certain plant fossils he had collected from Europe and America and coincided them together.

In 1885, one of the Austrian geologist, Edward Suess, presented the idea that the geological formations in the southern hemisphere were so similar that he was able to fit them together in the form of one large continent, which he called the land of Gondwana.

These observations clearly assume that the continents were not in the same place they are now. Then in 1912, the scientist Alfred Wegener came and put forward an explanation for this phenomenon, hypothesizing the theory of continental drift or the displacement of continents. The theory states that there was a large mass of land that formed a giant continent, which he called Pangea, meaning all the land, which is derived from the Greek language. Then the mother continent was shattered into pieces 200 million years ago. These pieces were displaced until they were formed in their current state.

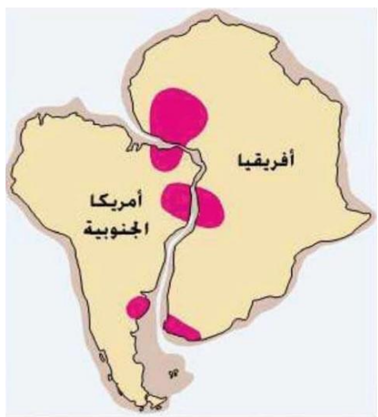
Although some scientists still support the existence of Pangea, they see that the continental merger was not complete and they prefer the presence of two large land masses, the first being Laurasia in the northern half, but it consists of Eurasia (Asia and Europe) and North America, contributing to the southern half, Gondwanaland was composed of South America - Africa - Arabian Peninsula - Madagascar – India.



Evidence of continental drift

1- Geographic evidence

This is clear from the agreement between the eastern coastline of the South American and the western coastline for the continent of Africa, which leads to the idea that they were united and then separated.



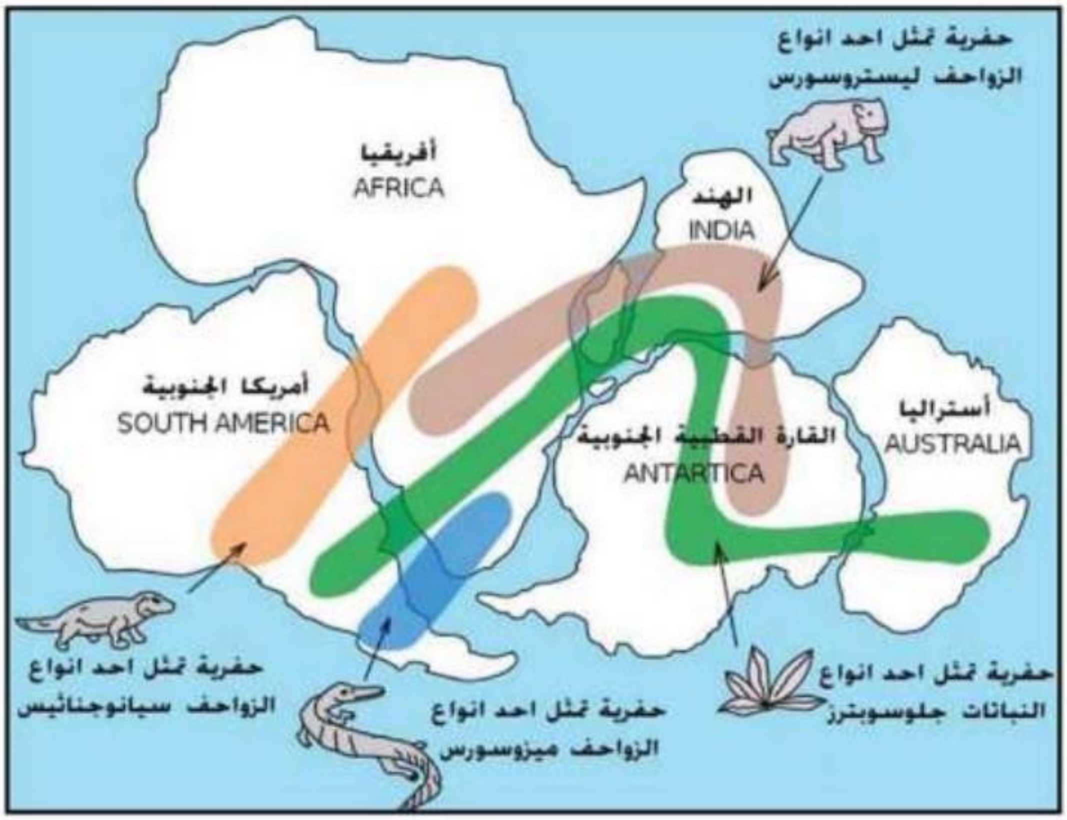
2- Evidences geological calendrer

Scientists have studied the chemical and physical features of rocks of ocean and beach. They found a great similarity between them, and they used radiation measurement to estimate their age. The rocks show that the rocks are in distant places such as India, Australia, and America, the southern regions can be related to each other based on their geological age.

3- Evidence from paleontology

Fossils of the plant Glossopteris are found in coal deposits of Pennsylvanian (Late Carboniferous) and Permian age on the five continents of Gondwana. Although pollen and spores are dispersed over large distances by wind, Glossopteris plants produced pollen that were too large to be transported by wind. If these grains moved across the oceans, it is likely that they would not remain able to survive and grow in salt water for any period.

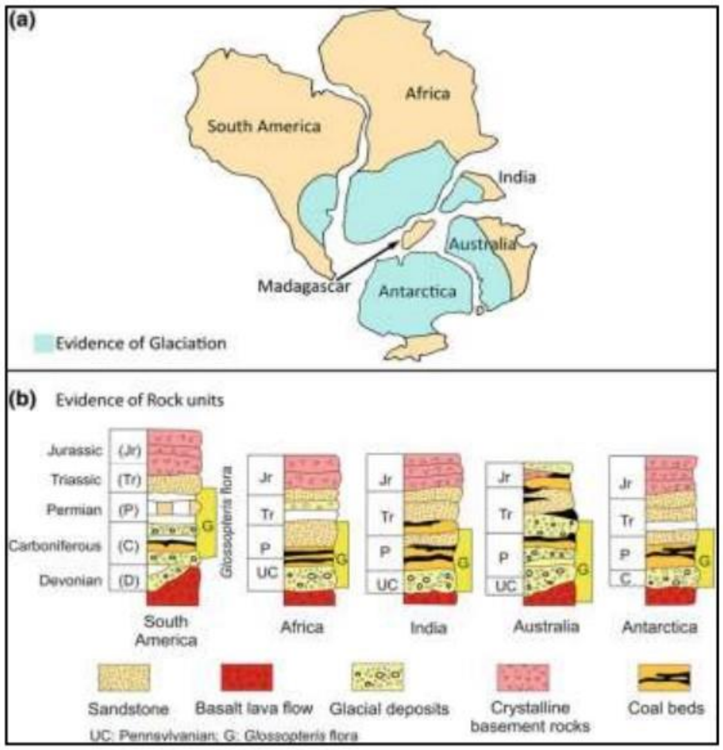
Animal fossils also provide strong evidence of continental drift. The genus Mesosaurus represents a freshwater reptile whose fossils are found in Permian rocks in specific areas in Brazil and South Africa only and are not found in other regions of the world. Because the physiology of freshwater animals is so different from that of saltwater animals, it is difficult to imagine how a freshwater reptile could swim across the Atlantic Ocean to find another freshwater environment nearly identical to its original environment. If Mesosaurus crossed the Atlantic Ocean, its remains should be scattered throughout the rocks of this ocean floor. Since the bottom of the Atlantic Ocean does not contain any remains of Mesosaurus



Distribution of plant and animal fossils

4- Evidence from distributions of glacial deposits

Latitude plays a major role in determining the prevailing climate In tropical regions the climate is warmer than in polar regions. Sedimentary rocks also reflect the climatic conditions prevailing at the time of their deposition, and some glacial deposits were found far from the current poles Such as India, Africa, South America, Australia, and Antarctica.



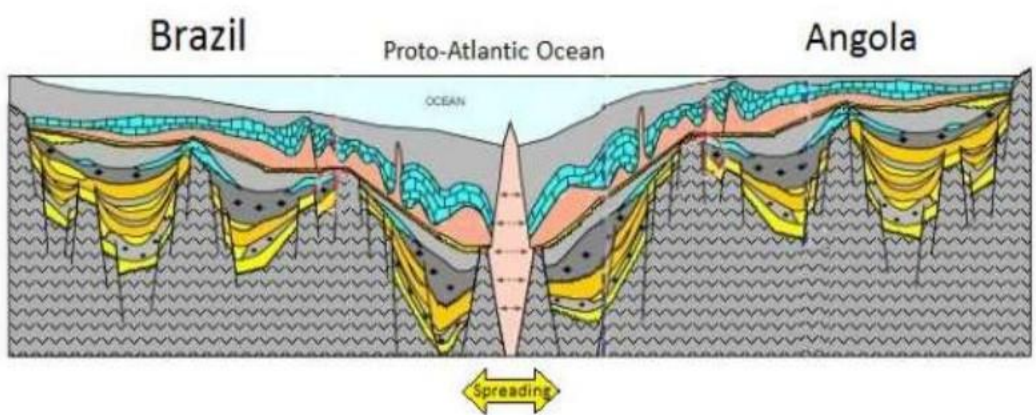
Glacier deposits in different areas.

5- Evidence from paleoclimatology

There is evidence of continental drift depending on the nature of the ancient climate, including coral reefs (the presence of warm, shallow seas) and coal layers that were formed from plants that lived in a hot climate. There are fossilized coral reefs and ancient coal deposits in places in the world that are characterized by extreme cold and perhaps extreme drought that do not allow for the existence of Coral reefs or swamps.

6- Geological evidence

On both sides of the Atlantic Ocean, there are many phenomena that suddenly end on the shores of one continent and reappear on the opposite continents. An example of this is the similar sedimentary sequence between Brazil (America) and Angola.



Geological cross section Brazil – Angola

7- Evidence from paleomagnetism

Some of the initial evidence for continental drift came from paleomagnetic studies of the Earth. In the early 1950s and beginning of the last decade, some geologists have studied the Earth's magnetic field, to reach a better understanding of the current magnetic field. This study, as usually happens in science, led to other important discoveries, including that ocean basins are geologically modern features, and that the continents have been active in the past, as Wagner and other researchers suggested.

The location of the Earth's magnetic poles roughly corresponds to the location of the Earth's geographic poles. When the magma cools, the minerals containing the iron arrange themselves in the direction of the Earth's magnetic field, when those minerals reach the Curie point, and the Curie point is the temperature above which the metal cannot maintain any permanent magnetism. Thus, both the direction and intensity of the Earth's magnetic field are recorded. This information can be used to determine the location of the Earth's magnetic poles and the latitude at which the rock existed during its formation.

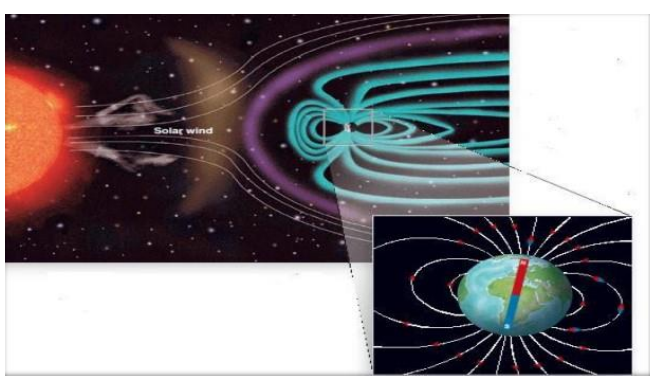
Studies carried out by geophysicist Runcorn K.S, and his workers have shown that the location of the ancient magnetic pole, which was determined from paleomagnetism in lava of different ages in Europe, has changed greatly. They found that during the past 500 million years, the North Pole had moved from the Pacific Ocean across eastern North Asia until it reached its current location near the Earth's geographic North Pole. This evidence of paleomagnetism can be interpreted in three ways:

- The first: that the continent of Europe remained fixed in place and that the north magnetic pole was the one that moved.
- The second: that the north magnetic pole was fixed, and that the continent of Europe was the one that moved.
- The third : It assumes that both the continent of Europe and the magnetic North Pole have moved

When paleomagnetic readings that were measured from several lava ridges of different ages in North America were projected onto a map, those readings indicated different locations for the North Magnetic Pole, different from those recorded by ridges of the same age in Europe. Moreover, analyzes of the eruptions of the mechanism from all continents indicated that each continent has a special series of magnetic poles. Does this mean that every continent has a different North Pole? It is difficult to accept this explanation considering the laws of physics that we know about how the Earth’s magnetic field created. Therefore, the best explanation for the wandering polar of the magnetic poles is that they remained in their current locations near the geographical poles, and that the continents were the ones that moved. When the continents are grouped into one block and the continents are matched together so that paleomagnetic records point to a single north pole, we find, as Wagner did.

Magnetic reversals: Numerous evidence has gathered since the early 1950s to prove that the Earth's magnetic field has reversed its polarity, that is, its direction periodically in the past. Such a change in polarization from the normal direction to the reversed direction is known as a magnetic reversal. The north and south magnetic poles exchange positions during a magnetic reversal.

Most of the evidence for magnetic reversals comes from lava deposits on the continents. A study of paleomagnetism in the lava rocks shows that the direction of the magnetic field there was opposite to the direction of the Earth's current magnetic field.



Earth magnetic field

8- Sea floor spreading

Interest in marine science research led to the creation of comprehensive maps of the world's ocean basins. These maps showed that the ocean floors contain the most important mountainous heights on Earth, which are known as the mid-ocean ridge, and that the Mid-Atlantic Ridge is part of a ridge system spread throughout the entire continent, with a length of more than 65,000 km. The width of the mid-ocean ridge ranges between 500 km and 5000 km, occupying half the area of the ocean floor in some places. These Mid-Atlantic ridges differ from those placed on the earth surface, where they composed from basaltic rocks. It has also been proven that ocean ridges are characterized by high heat flow, earthquake and volcanic activities. It is located along a narrow area located centrally at the top of these diffractions and is known as rift zones.

Harry Hess intensified his research in the Pacific Ocean during his service in World War II, where he discovered guyots, flat-topped volcanic islands submerged under the sea's surface, which provided geologists with further evidence of the movement of the ocean floor away from the mid-ocean ridge.

Hess published his discovery of geotes and the results of his other studies in an important paper in 1962 in which he proposed the hypothesis of sea floor spreading. Hess also explained continental movement. Hess suggested that the continents do not move across or through the oceanic crust, but rather that both the continents and the oceanic crust move together and that they are part of large plates. According to Hess's hypothesis, the oceanic crust separates at the mid-ocean ridge, where a new oceanic crust is formed from the rising magma. When the magma cools, the newly formed oceanic crust moves sideways away from the rift. Thus, it can be explained how volcanic islands formed at or near the ridge tops later became geotes.

By studying the distributions of earthquakes on the world map and isolating them into areas known as Benioff zones, which are centered and agree with diffraction Mid- Ocean oceanic ridges and oceanic valley areas Oceanic trenches helped confirm the idea of ocean expansion.

Sea floor spreading

9. Plate tectonic theory

theory dealing with the dynamics of Earth's outer shell the lithosphere that revolutionized Earth sciences by providing a uniform context for understanding mountain-building processes, volcanoes, and earthquakes as well as the evolution of Earth's surface and reconstructing its past continents and oceans. The concept of plate tectonics was formulated in the

1960s. According to the theory, Earth has a rigid outer layer, known as the lithosphere, which is typically about 100 km (60 miles) thick and overlies a plastic (moldable, partially molten) layer called the asthenosphere. The lithosphere is broken up into seven very large continental- and ocean-sized plates, six or seven medium-sized regional plates, and several small ones. These plates move relative to each other, typically at rates of 5 to 10 cm (2 to 4 inches) per year, and interact along their boundaries, where they converge, diverge, or slip past one another. Such interactions are thought to be responsible for most of Earth's seismic and volcanic activity, although earthquakes and volcanoes can occur in plate interiors. Plate motions cause mountains to rise where plates push together, or converge, and continents to fracture and oceans to form where plates pull apart, or diverge. The continents are embedded in the plates and drift passively with them, which over millions of years results in significant changes in Earth's geography.

This theory is called by multiple names, including the theory of tectonics of the earth and the theory of tectonic plates, and the term tectonic refers to the meaning of construction, so the concept of the theory refers to the movement of the panels leading to the construction of the earth's crust.

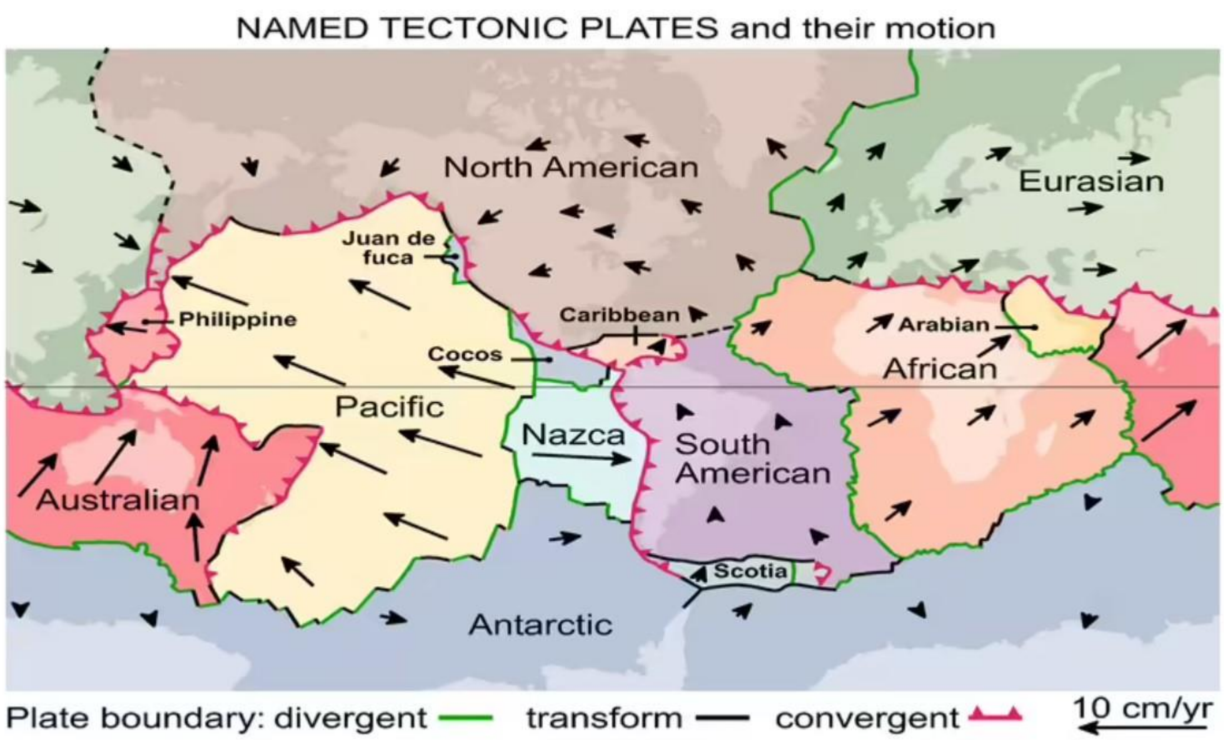
The theory of tectonic plates states that the solid geosphere consists of a group of plates ranging in thickness of about 100 km These plates float above the asinosphere and move horizontal movement approaching or moving away from each other and the speed of movement of these pieces is estimated at 1-18 cm each year.

Movement of tectonic plates: Tectonic plates move along the boundaries between them, each plate moves independently of the other, and because of this movement, the boundaries are subjected to continuous stress, which results in many phenomena such as: -1 Volcanic eruption. -2 earthquakes activity. 3. sea floor spreading. 4. Magmatic flow. -5 Build mountains.

The size and location of these plates change with time The division of tectonic plates in terms of size into:
A- 7 huge plates: the Pacific Ocean plate - the Asian-European plate, which holds Asia and Europe, half the Atlantic Ocean floor and half the Indian Ocean floor - North American plate -

South American plate - Australian plate - Antarctic plate - African plate.

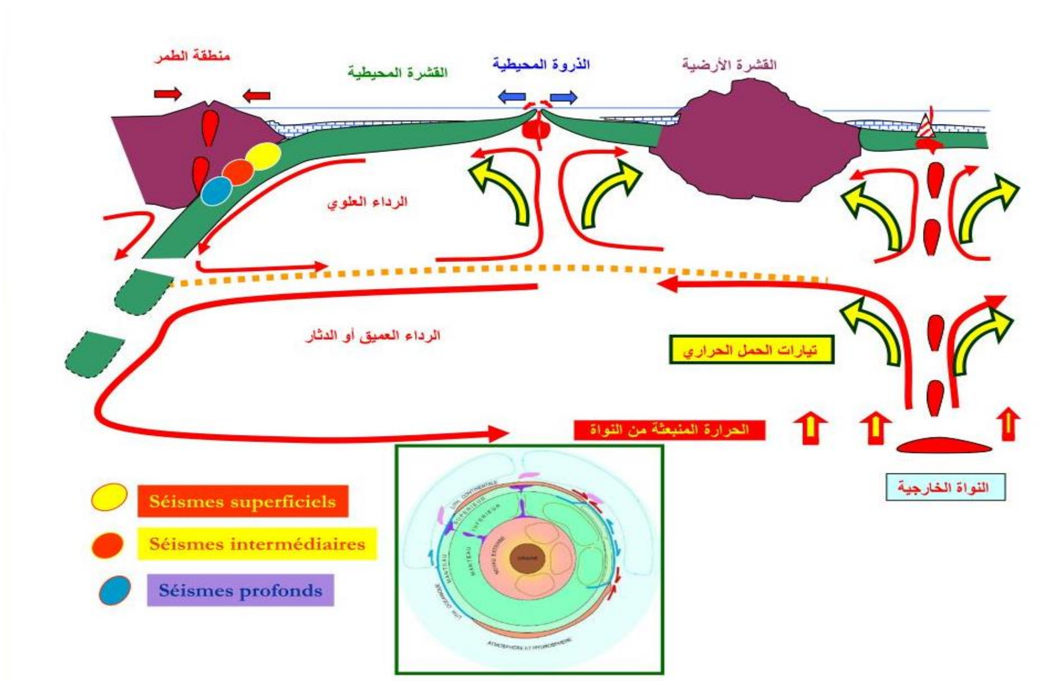
B - Some medium and small plates: It was noted that some plates carry part of a continent, and some plates carry part of the ocean, some of them carry part of a continent and part of the ocean together moving together at the same time, contrary to what was believed in the past that continents float on the bottom of the ocean. Such as the Nazca plate – Arabian plate – the Philippine plate – the Caribbean plate – Southeast Asia



<u>Causes of plate tectonic movements</u>

Reasons for the movement of the earth plates: First - Convection currents: As explained by Holmes, the splitting of the continental mass and the drift of its two parts can be imagined as follows: -1 The upward convection currents press on the continental crust to bend. -2 The upper part of it is cold and responds to flexion by splitting. 3. The split masses budge, forming ordinary faults with a groove crack in the middle. 4. The faults extend to approach the upper layer of the mantle (asthenosphere). 5- Magma flows upwards and the continental mass is worried about two parts and fills the space between them. 6- With time, the area occupied by magma expands, which quickly freezes, forming an oceanic crust that also suffers from splitting and the continued flow of magma and freezing, and thus a new ocean is formed that displaces the two continental masses aside. - It is clear from the above that the convection currents in the upper layer of the mantle are the engine that displaces the parts of the earth's crust but is responsible for dividing them into large sectors later called plates or tectonic plates and the accompanying phenomena.

Hot spots: Areas located in the middle of the oceanic plates are relatively free of tectonic activity. Therefore, this rule may be anomalous, as in the case of the Hawaiian Islands, located in the middle of the Pacific Ocean, and these islands are volcanic islands for two reasons, the first of which is that they are located on hot spots in the upper regions of the earth's core. The second reason is that the heat rising from these points through the mantle of the earth and the earth's crust to reach the surface of the earth causes the fusion of part of the oceanic crust and from the top of the mantle, and this leads to the rush of molten material to the surface, forming volcanic islands.

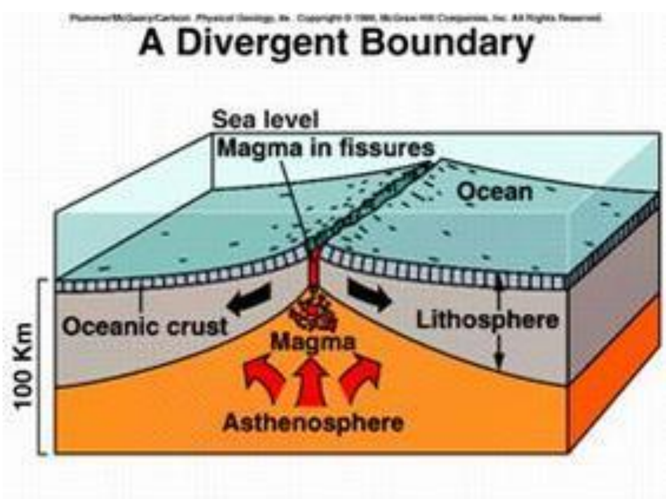


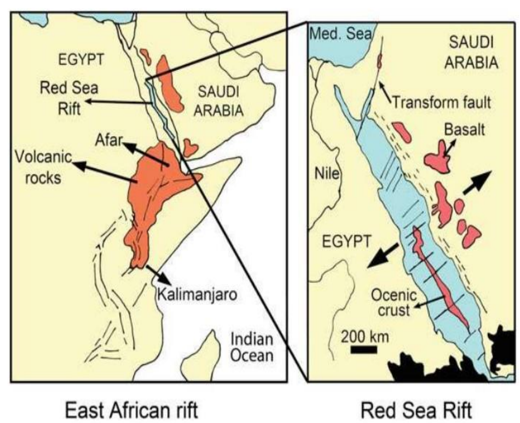
Mechanism of convection currents

Plate boundaries

A- Divergent boundaries (constructive)

The plates move away from each other, like the divergence of the South American and African plates, due to the activity of upward convection currents and the continuous flow of magma between them to push them away from each other, as happens around the mid-ocean ridge. These areas are characterized by a slow flow of magma. An example of this type is the Red Sea and the rifts of the valley of Africa, which predicts the taper of the continent of Africa in the future.





Diversion boundaries – red sea rift

B- Convergent plates

Conversely, in places where two plates come together, a convergent boundary occurs. The impact of the plates in those places can cause the edges to buckle and push up to form a mountain range, or else bend to create a deep trench in the ocean floor. Chains of volcanoes often form parallel to the boundaries. Convergent boundaries create continental crust but destroy crust that's part of the ocean floor.

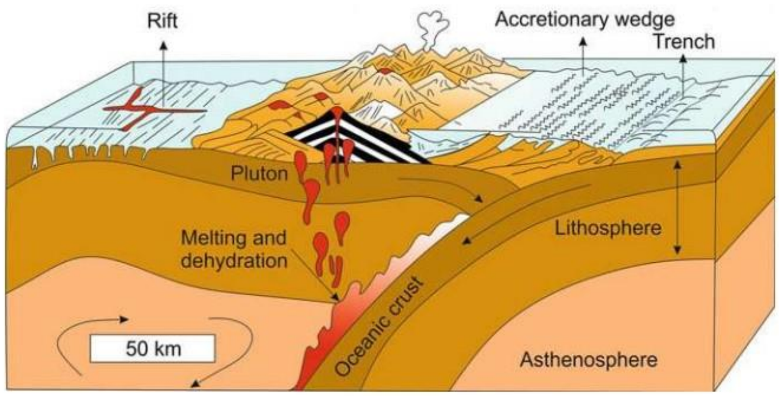
I- Ocean – ocean collision

II- Continental – Continental collision

III- Ocean – Continental collision

I- Ocean- ocean collision

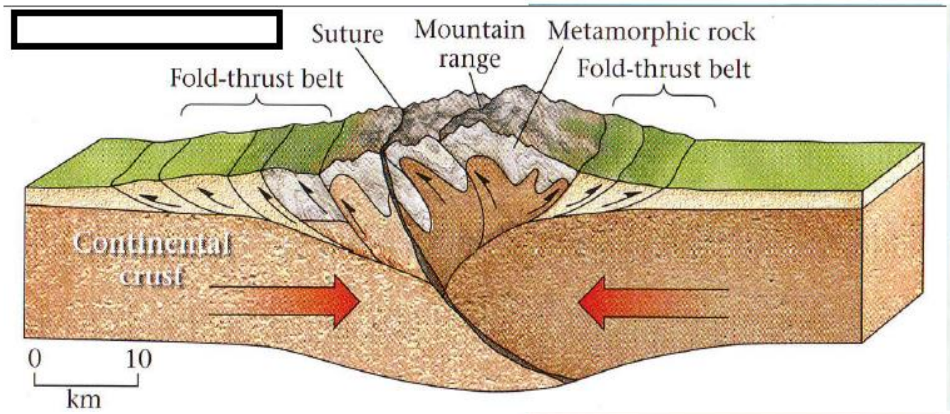
When two ocean plates collide, one of which disappears beneath the other and forms what are known as marine canyons, the sunken plate becomes a wicker band where it partially melts and consumes and produces arcs of volcanic islands such as Mariana Island and the Island of the Philippines around the western tip of the Pacific Ocean.



Ocean -ocean collision

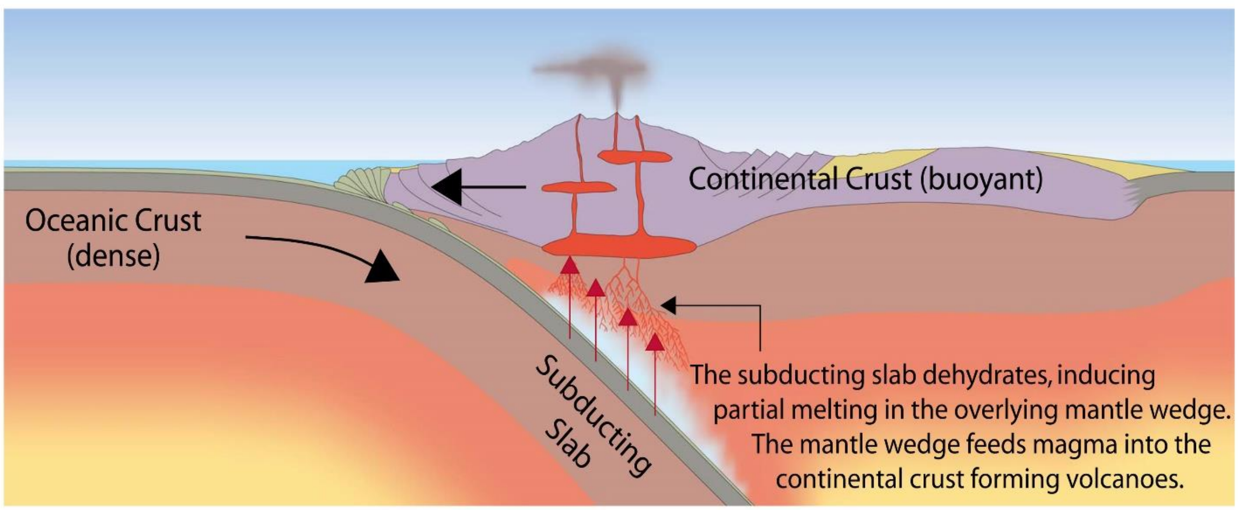
II- Continent – continent collision

When one continental plate collides with another, this results in the formation of belts of folded mountain ranges that are also affected by propulsion faults along the collision range. An example of this is the Himalayas and the Tibetan plateau as a result of the collision of the Indian and Eurasian plates.



III- Continent – Ocean crust collision

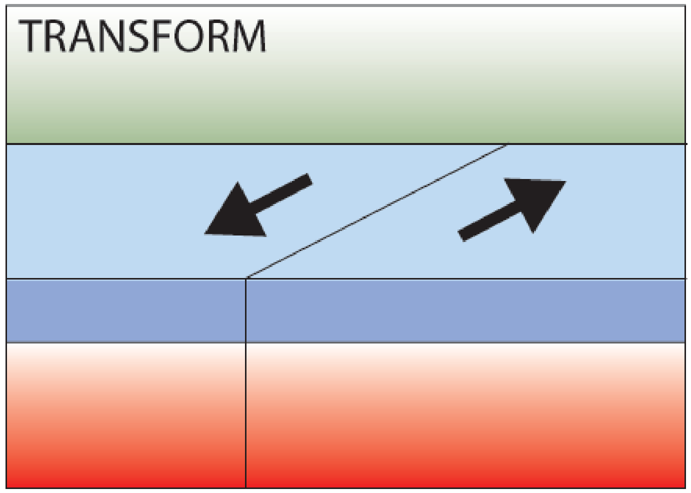
When the collision of an oceanic plate and another continental slides and dives the oceanic plate below the continental as a result of its high density and this diving area is known as the scope of inclusion and in which the temperature of the oceanic plate rises and then followed by partial melting and consumption of the tip of the oceanic plate and produces so-called volcanic islands.



Continent - Oceanic crust collision

C- Transitional borders

In this pattern, there is no divergence or collision of the plates, but they move along each other in a reverse direction along faults called transition faults, in this case a new lithosphere is not formed as in the middle of the oceans and the lithosphere is not consumed as in the inclusion zone. One of the most famous of these areas is the San Andreas Fault in California, America.



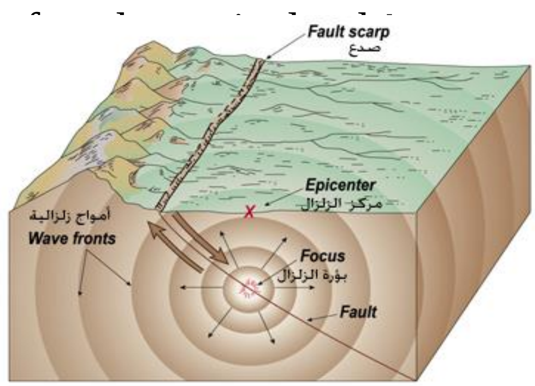
San andreas fault

9- Endogenic process

Earthquakes

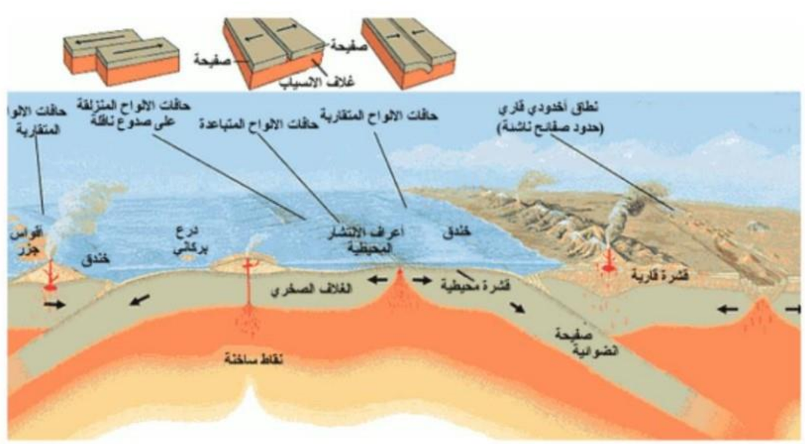
An earthquake is what happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called the fault or fault plane. The location below the earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface of the earth is called the epicenter.

Sometimes an earthquake has foreshocks. These are smaller earthquakes that happen in the same place as the larger earthquake that follows. Scientists can't tell that an earthquake is a foreshock until the larger earthquake happens. The largest, main earthquake is called the mainshock. Mainshocks always have aftershocks that follow. These are smaller earthquakes that occur afterwards in the same place as the mainshock. Depending on the size of the mainshock, aftershocks can continue for weeks, months, and even year



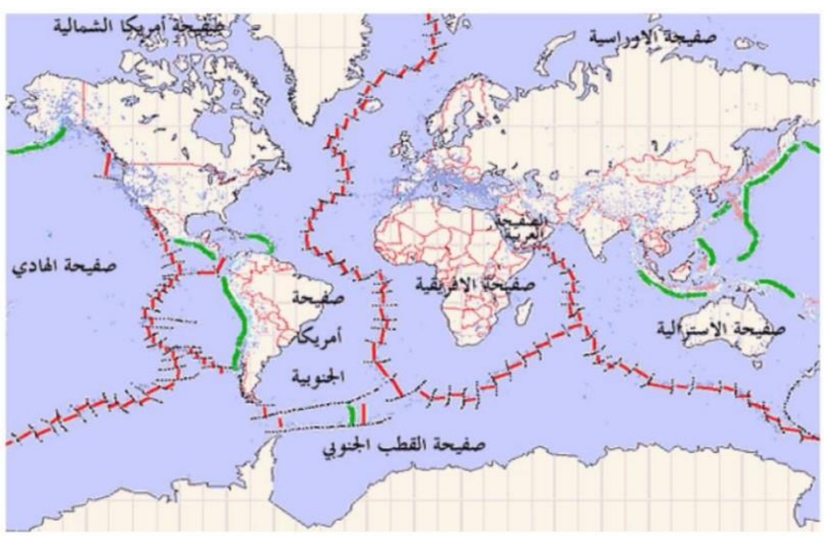
<u>What causes earthquakes and where do they happen?</u>

The earth has four major layers: the inner core, outer core, mantle, and crust. The crust and the top of the mantle make up a thin skin on the surface of our planet. But this skin is not all in one piece – it is made up of many pieces like a puzzle covering the surface of the earth. Not only that, but these puzzle pieces keep slowly moving around, sliding past one another, and bumping into each other. We call these puzzle pieces tectonic plates, and the edges of the plates are called the plate boundaries. The plate boundaries are made up of many faults, and most of the earthquakes around the world occur on these faults. Since the edges of the plates are rough, they get stuck while the rest of the plate keeps moving. Finally, when the plate has moved far enough, the edges unstick on one of the faults and there is an earthquake.



In light of this... A group of weak areas in the earth's crust have arisen on the ground, which are considered centers of seismic activity or vents through which the earth breathes the anxious energy inside it that needs to be launched, They are called "earthquake belts" and these belts are

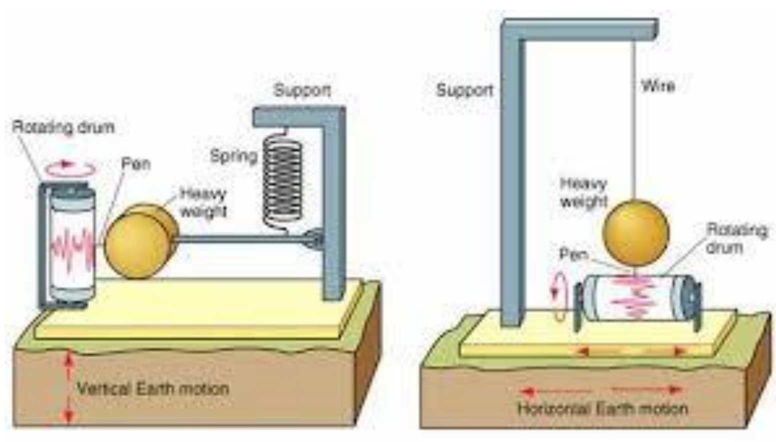
- The Pacific belt extends from Southeast Asia along the Pacific Ocean northward.
- The West North American belt that runs along the Pacific Ocean
- The belt of the Western Americas, which includes Venezuela, Chile, and Argentina.
- Mid-Atlantic belt



Distribution of earthquakes belts

Recording earthquakes

Earthquakes are recorded by instruments called seismographs. The recording they make is called a seismogram. The seismograph has a base that sets firmly in the ground, and a heavy weight that hangs free. When an earthquake causes the ground to shake, the base of the seismograph shakes too, but the hanging weight does not. Instead, the spring or string that it is hanging from absorbs all the movement. The difference in position between the shaking part of the seismograph and the motionless part is what is recorded.



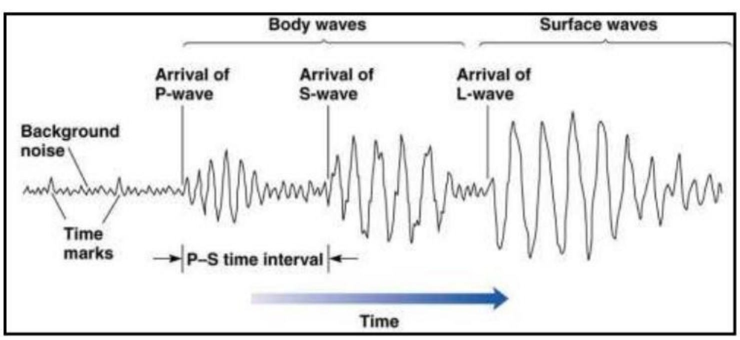
The earthquake log for each earthquake consists of three sections:

The first section, which is the primary waves, which are longitudinal waves, the fastest waves, and the first to reach seismic machines, and their speed ranges from 5.5 to 13.8 km / second.

The second section includes secondary waves, which are transverse waves emitted by the oscillation of rock grains in a direction perpendicular to the direction of propagation of the primary waves, and these waves are slower than the first and range in speed from 3.2 to 7.3 km/s.

The third section is surface waves, which are long-range transverse waves that propagate from the epicenter of the earthquake, and are the slowest of the three types, with speeds not exceeding 4.4 km/s.

Primary and secondary waves propagate within the Earth's crust in an almost circular path. As for the long waves, they travel on the surface of the earth, so they reach the last waves, but they cause most of the destruction and destruction.



Types of seismic waves

Seismic waves are generated by the release of energy during an earthquake. They travel through the earth like waves travel through water. The study of seismic waves and earthquakes is called seismology, which is a branch of geophysics. Two types of seismic waves are generated at the earthquake focus:

- Body waves spread outward from the focus in all directions.
- Surface waves spread outward from the epicenter to the Earth's surface, similar to ripples on a pond. These waves can move rock particles in a rolling motion that very few structures can withstand. These waves move slower than body waves.

There are two types of Body Waves:

1. Primary Wave (P wave): Compressional wave (travels in the same direction the waves move). Example: A slinky.

* Very fast (4-7 km/second)

* Can pass through a fluid (gas or liquid)

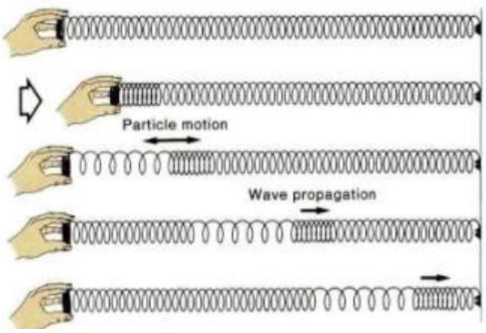
* Arrives at recording station first

2. Secondary Wave (S wave): Transverse wave (travels perpendicular to the wave movement). Example: Shaking a rope.

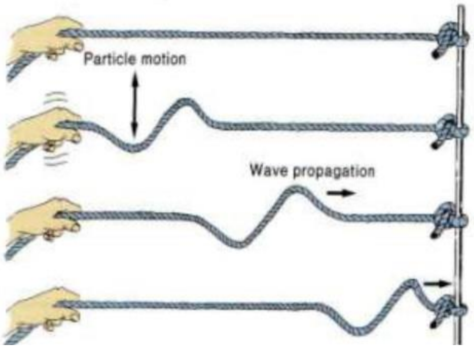
• Slower moving (2-5 km/second)

• Caused by a shearing motion

• Cannot pass through a fluid (gas or liquid)

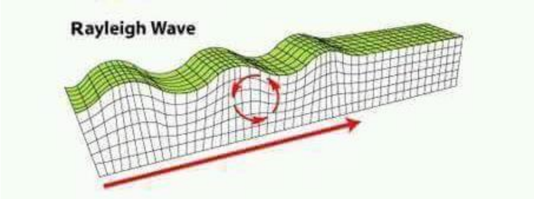


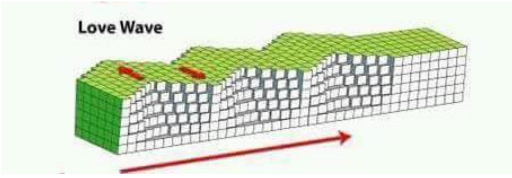
Primary waves



secondary waves

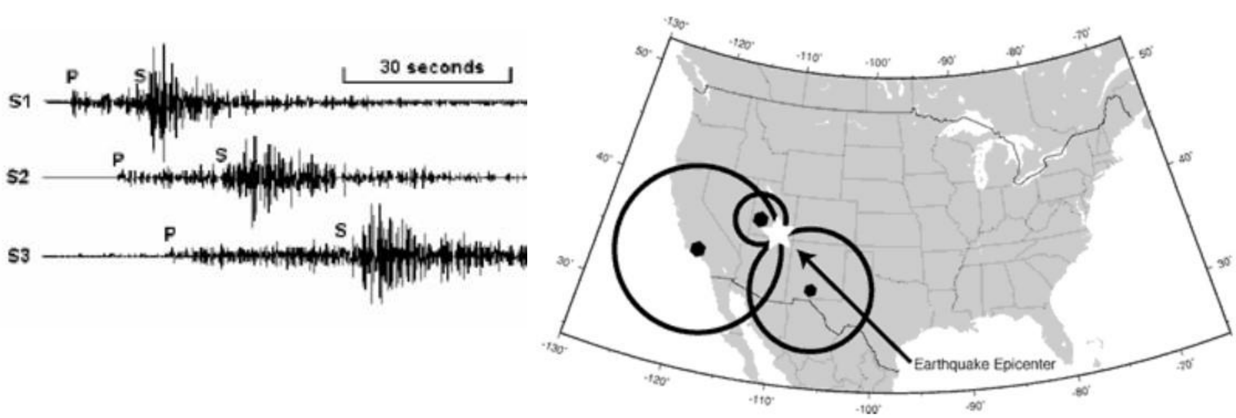
Surfaces waves are produced when earthquake energy reaches the Earth's surface. Surface waves move rock particles in a rolling and swaying motion, so that the earth moves in different directions. Two types of surface waves love and Rayleigh.





<u>Earthquake epicenter Determination</u>

It was possible to calculate the distance of the epicenter from the monitoring station by taking advantage of the different velocities of seismic waves in determining the epicenter. It refers in a way to the epicenter of the earthquake in the ground by knowing the time difference between the time of arrival of each type of wave and the speed of these waves and to adjust the process of determining the surface center of the earthquake draw three circles so that the radius of each of them represents the distance between the surface center of the earthquake and each of the monitoring stations and let it be three stations and where the circles intersect the surface center of the earthquake as shown in the figure



Determination epicenter of earthquake

Can scientists predict earthquakes?

No, and it is unlikely they will ever be able to predict them. Scientists have tried many different ways of predicting earthquakes, but none have been successful. On any particular fault, scientists know there will be another earthquake sometime in the future, but they have no way of telling when it will happen.

Volcanoes

It is a terrestrial or marine terrain that releases or emits hot molten materials with associated vapors and gases from the depths of the earth's crust, and this occurs through craters or cracks. Molten material accumulates or flows depending on its type to form different landforms, including conical hills or high volcanic mountains such as those in Yellowstone National Park in North America.

Example of volcano

Causes of volcanoes

When the temperature rises to the melting point of rocks in the lower Earth layer, the so-called magma is formed. Magma rises upwards whenever it finds a place, until it collects in ground cavities just below the earth's crust. As the pressure rises higher, the lava flows first in the form of an explosion and this explosion occurs. Due to the high vapor pressure of dissolved gases inside magma, which leads to the spread of clouds of volcanic ash that may cover hundreds of miles, and lava runoff may reach several miles, and then its flow speed decreases with time. On weak areas, cracks occur in the earth's crust. The magma rushes through it to

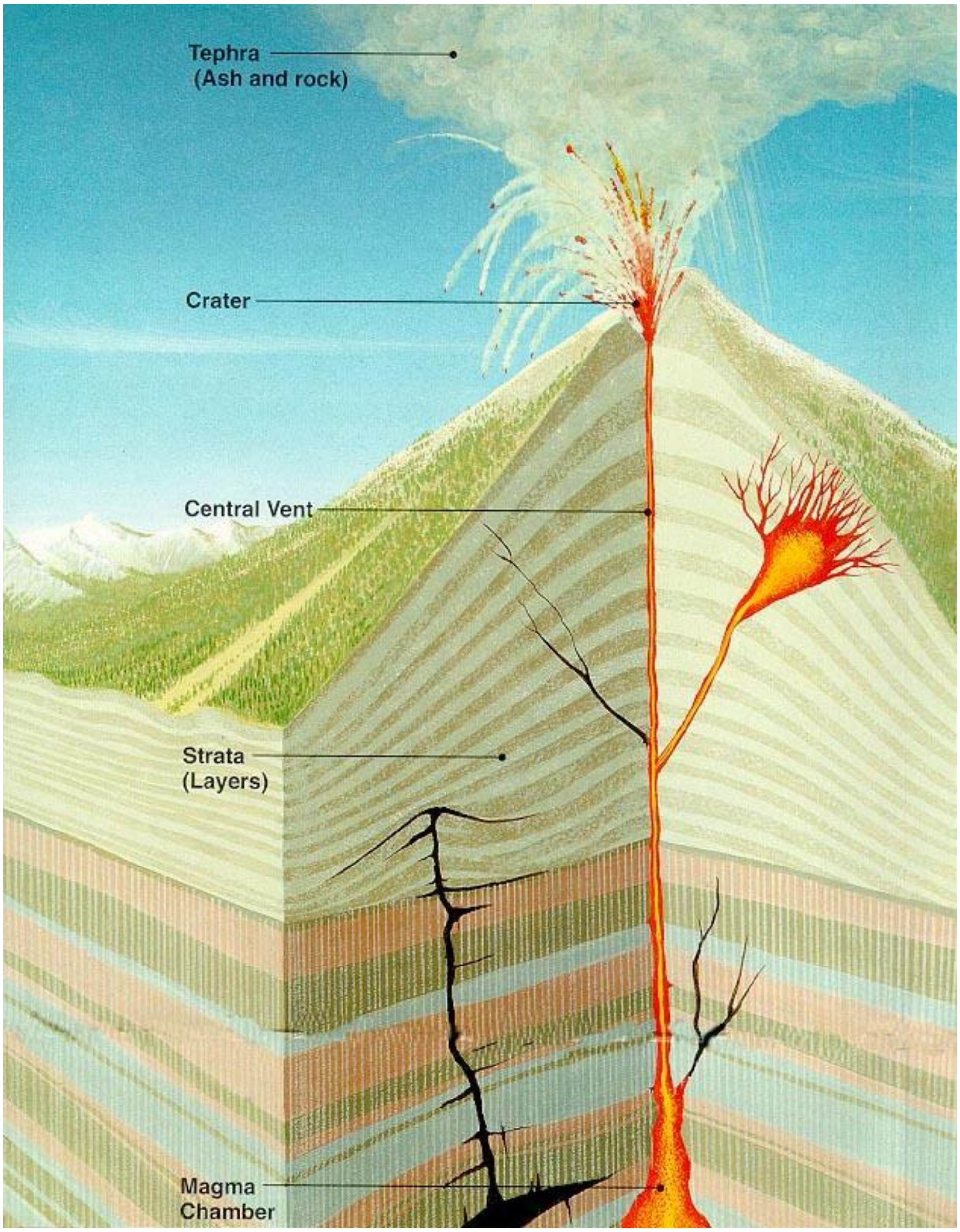
The main parts of the volcano

Volcanic cone: It is the sloping sides made up of lava. It is the torrent of magma. The mineral substances that a volcano ejects from its crater and all or some of it is in a molten state, and the pulp is magma that flows on the surface and then hardens.

Crater: A small funnel-shaped crater or a bowl on the surfaces of planets or other objects in the solar system. Most craters on Earth's surface are formed by volcanic activity. Most of these craters are caused by explosions. which blow up embers and other rubble arising from volcanic eruptions. It is rare for such craters to exceed two kilometers in size from side to side. Other craters form when the Earth's surface collapses following lava rebounding from above. Both the depression occupied by the volcanic lake in Oregon in the United States and the Kailuya crater in Hawaii may have been caused by a collapse. Descending craters with a diameter of more than one kilometer are called huge craters and less volcanic craters are called small craters. Volcanic craters are more common on the Moon and on planets other than Earth. But most of the craters on these objects are impact craters formed by the influence of meteorites.

Chimney or central vein: It is the pipe that connects the underground magma reservoir to the crater, from which the magma rises. Volcanic material rushes into the crater. It is sometimes known as the neck of a volcano. Besides the main chimney, the volcano may have several chimneys connected to the secondary craters.

Tephra: a cloud of vapors, gases, and volcanic ash



Volcanic projectiles

Solid rock debris, molten materials and gases emerge from volcanoes when erupting.

Rock debris: Solid rock debris of various types and sizes usually emerges as a result of volcanic eruptions.

Volcanic projectiles in the first period of the eruption The volcano spews large projectiles called volcanic bombs (greater than 64 mm.) They are mostly oval in shape. The following figure shows some forms of volcanic bombs. Projectiles may be in the form of small volcanic pebbles and may increase slightly in size until they reach a diameter of about (2 64 mm. Lapilli**).** In this case, it is called Lablay, and there are also the most accurate types of projectiles, which is ash or volcanic dust (less than 2 mm.) that is carried by the wind for long distances before being deposited and gases.

Gases: Water vapor gases come out of volcanoes during their activity, and it emanates in large quantities, forming huge clouds in which dust and other gases mix with it. These vapors condense, causing heavy rain to fall in the vicinity of the volcano. Explosions and rainfall are accompanied by electric lights arising from the friction of volcanic ash grains with each other and as a result of atmospheric turbulence, except for very hot water vapors, the volcano emits multiple gases, the most important of which are hydrogen, chlorine, sulfur compounds, nitrogen, carbon compounds and oxygen.

Lava

There is also liquid material spewed by the volcano, known as lava, which is a mass of molten material. They rise in the trachea relatively quickly and then come to the surface and spread on the sides of the volcano where they gradually decrease until they stand permanently. Its speed ranges from centimeters per hour to kilometers depending on its composition. The degree of fluidity of lava varies according to its chemical composition, there are basic lava, which is more liquid and faster than acid lava because the latter are rich in silicon dioxide, which hardens quickly when in contact with air, and the most important component of basic lava is basalt rock, and for this we find that it is the most widespread volcanic rock on the surface of the earth.

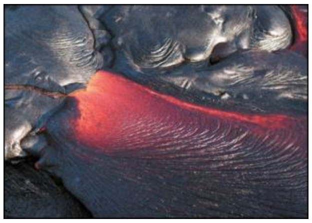
Examples include the basalt of Abu Zaabal and the basalt in Mount Abu Rawash. This indicates that volcanic activity occurred in these two places at some point.

When the lava cools, the features of its surfaces are used to classify it into:

a- **Pahoehoe**. Overflows, such as ropes or hair braids, their surface is smooth, and they are basaltic in composition, large liquidity.

b- **ah ah lava (AA):** With rough surfaces and very sharp bumps (causing injuries and severe pain).

c-**pillow lava**: They form when the rash and flow are under water.



A volcano usually consists of a cone, a stalk, and a crater. But when the diameter of the crater exceeds a kilometer, it is called Caldera, which also consists of the collapse of the roof of the magma chamber. Sometimes magma does not flow from the upper crater of the volcano and flows from lateral cracks. There are other phenomena associated with volcanoes.

Caldera

Distribution of volcanoes

Volcanoes are scattered in many areas on the Earth's surface, and in most cases, they follow certain lines that separate and show the great tectonic plates

The range that surrounds the coasts of the Pacific Ocean, sometimes known as the Ring of Fire, extends on the eastern coasts of that ocean over the Andean highlands to Central America and Mexico, and over the highlands of western North

America to the Aleutian Islands and from there to the coasts of East Asia to the islands of Japan and the Philippines, and then to the islands of Indonesia and New Zealand.

There are many volcanoes in the Pacific Ocean and some of them are great magnificence that originated at its bottom and appeared tall above its water level. Including the volcanoes of the Hawaiian Islands, whose bases in the ocean rest at a depth of about 5000 m, and rise above the surface of its waters more than 4000 m, thus reaching a total height from the bottom of the ocean to its peaks about 9000 m.

Southern Europe borders the Mediterranean Sea and the islands adjacent to it. The most famous active volcanoes are Vesuvius near Naples, Italy, Etna on Sicily island, and Stromboli (Mediterranean Lighthouse) in the Lipari Islands.

. The highlands of Western Asia and the most famous volcanoes are Ararat and Yuzns.

The eastern region of Africa and the most famous volcanoes of Kilimanjaro

The areas of the lava flow associated with volcanic activity on the French island of Reunion in the sea of perennial erupting volcanoes are very sparse, the Caribbean between 1972 and 2000 on the surface of including the Strampoli volcano, in the Lipari Islands, near the island of Sicily, known as the Lighthouse of the Sea Basin. Intermittent erupting or relatively calm mid-white volcanoes are common on Earth, where volcanic activity subsides for a period of time and then regenerates during another period, including Aetna on Sicily.

There are dormant volcanoes, in which volcanic activity has long since completely subsided and became subject to erosion carving, which carves the sides of the volcanic cone; examples of volcanic structures include Chibrook in Mexico, and Devilstor, in the state of Wyoming in the United States of America. The number of active volcanoes is estimated at about 600 volcanoes distributed on the surface of the Earth, most of which are concentrated in belts roughly equivalent to areas of cracks, fractures and natural faults distributed along newly formed mountain ranges.

There are two large distributions of volcanoes.

First : The Fire Belt Circle, located in the Pacific Ocean

Second, it starts from the Baluchistan region to Iran, Asia Minor, the Mediterranean Sea, reaching the Azores and Canary Islands and turning around the Western Andes in the United States. Here are some of the names of volcanoes in these areas.

Mexico: 10 volcanoes, including parecotene, which first erupted in 1934, South America: 2, New Zealand: 6 volcanoes, New Joanna: 30 volcanoes, Philippines: 20 volcanoes , Japan: 40 volcanoes

Mediterranean axis region: From west to east we find the following volcanoes in this region: Azores: 5 volcanoes, Canary 3: volcanoes, Italy: 15 volcanoes, including Vesuvius, Stromboli and Volcano volcanoes, Adriatic region: 9 volcanoes, including Mount Pelee, Arabia and Asia Minor: 6 volcanoes, including Jabal al-Arab eruption in Syria

African Canyon area: Hawaii: 5 volcanoes**,** Galapagos Islands: 3 volcanoes, Iceland: 27 volcanoes, Central Africa: 5 volcanoes , East Africa: 19 volcanoes

Pacific: Alaska: 20 volcanoes, including Kattamai, Shishuddin, Canada: 5 volcanoes, including Wrangel.

USA: 8 volcanoes, including Rainer A volcano is a terrestrial or marine terrain that emerges or emits a crust. Magma accumulates or flows according to its type to form different landforms, including the famous high cone-volcanic mountains.

Classification of volcanoes

Based on activity classified into three types

a- Active: when the volcano is erupting or showing signs of activity from earthquakes or gas emissions

b- Static volcano: When the volcano shows no signs of activity, but it can erupt, it may have already erupted within the past ten thousand years.

c- Dormant volcano: when the volcano has not erupted in the last ten thousand years, or the volcano has completely eliminated its magma supply.

Based on nature

a- Quiet type: does not exceed the eruption of some vapors and gases.

b- Medium type: ejaculates some quantities of lapa in quiet quantities.

c- Violent type: includes violent explosions with clouds of gases, volcanic ash and crumbs released.

Based on pattern (volcanic eruptions)

a- Hawaiian: In a Hawaiian explosion, thin-textured magma is liquid as gases mixed with it can easily leak out; so violent explosions do not occur.

b- Stromboli: In a Stromboli explosion, magma is less thin than the magma found in the Hawaiian explosion, meaning that the gases mixed with it cannot easily escape, and that there will be violent explosions. The lava comes out in the form of a huge yellow fire fountain. The gap is ejected into a large block of rock, and those masses fall around the gap and take shape.

c- Pleni: In the explosion Blainey, the magma is thick, so it is difficult to escape the gases and accumulate underground. The pressure leads to pushing the rock upwards, and eventually the gases explode violently coming out of the rock, and the force of the explosion leads to the formation of a column of gas whose height increases 2. When the gas explodes, it breaks the magma into small pieces and throws it high with the kilometer column of gas, and when these magma pieces cool, they turn into a white stone called pumice.

11. Exogenic process

These processes derive energy from sunlight and cause destructive changes in the surface of the earth's crust. If it were not for the internal factors that restore the height of large parts of the earth's surface, this surface would have been flat and devoid of terrain. In fact, surface factors have a destructive effect, which is known as erosion, and a structural effect, which is known as deposition.

1- Denudation

Denudation is the geological processes in which moving water, ice, wind, and waves erode the Earth's surface, leading to a reduction in elevation and in relief of landforms and landscapes.

Denudation incorporates the mechanical, biological, and chemical processes of erosion, weathering, and mass wasting.

Denudation can involve the removal of both solid particles and dissolved material.

2- Deposition

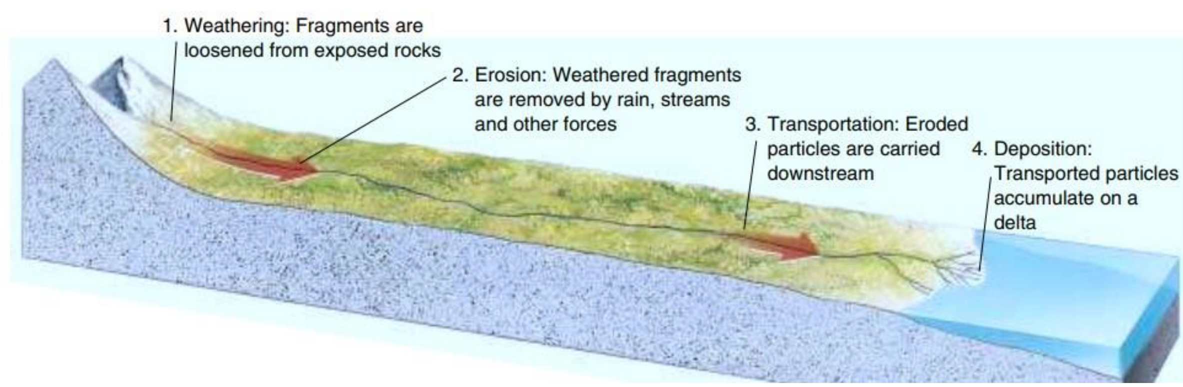
The aforementioned erosion factors are destructive factors, which turn rocks into waste and rubble, and on these wastes and rubble begin opposite factors to erosion factors, which are sedimentation factors, transport factors, whether rivers or winds, carry waste rocks or fragmented rocks and transport them from their first places to low-level places as permitted by geographical conditions, weight and portable size of granules, and by gravity these rock waste falls and is deposited in the form of layers called sedimentary rocks (Sedimentary Rocks) An example of such clay rocks that are deposited at the rivers.

Weathering

is the decomposition and disintegration of rocks and minerals at the Earth's surface. Weathering itself involves little or no movement of the decomposed rocks and minerals. This material accumulates where it forms and overlies unweathered bedrock.

Erosion

is the removal of weathered rocks and minerals by moving water, wind, glaciers, and gravity. After a rock fragment has been eroded from its place of origin, it may be transported large distances by those same agents: flowing water, wind, ice, and gravity. When the wind or water slows down and loses energy or, in the case of glaciers, when the ice melts, transport stops, and sediment is deposited. These four processes—weathering, erosion, transportation, and deposition—work together to modify the Earth's surface.



A schematic view shows weathering, erosion, transport, and deposition of sediment.

Mechanical and chemical weathering

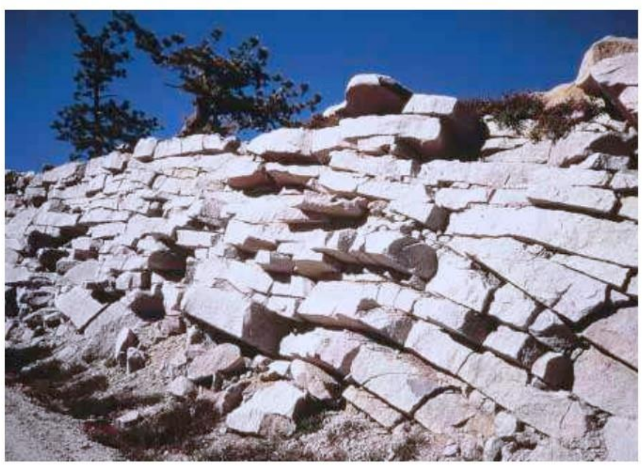
The environment at the Earth's surface is corrosive to most materials. An iron tool left outside will rust. Even stone is vulnerable to corrosion. As a result, ancient stone cities have fallen to ruin. Over longer periods of time, rock outcrops and entire mountain ranges wear away. Weathering occurs by both mechanical and chemical processes. Mechanical weathering reduces solid rock to rubble but does not alter the chemical composition of rocks and minerals. In contrast, chemical weathering occurs when air and water chemically react with rock to alter its composition and mineral content. These chemical changes are analogous to rusting in that the final products differ both physically and chemically from the starting material.

Mechanical weathering

Mechanical weathering breaks large rocks into smaller ones but does not alter the rock's chemical nature or its minerals. Think of grinding a rock in a crusher; the fragments are no different from the parent rock, except that they are smaller. Five major processes cause mechanical weathering: pressure-release fracturing, frost wedging, abrasion, organic activity, and thermal expansion and contraction. Two additional processes—salt cracking and hydrolysis expansion—result from combinations of mechanical and chemical processes.

Pressure-release fracturing

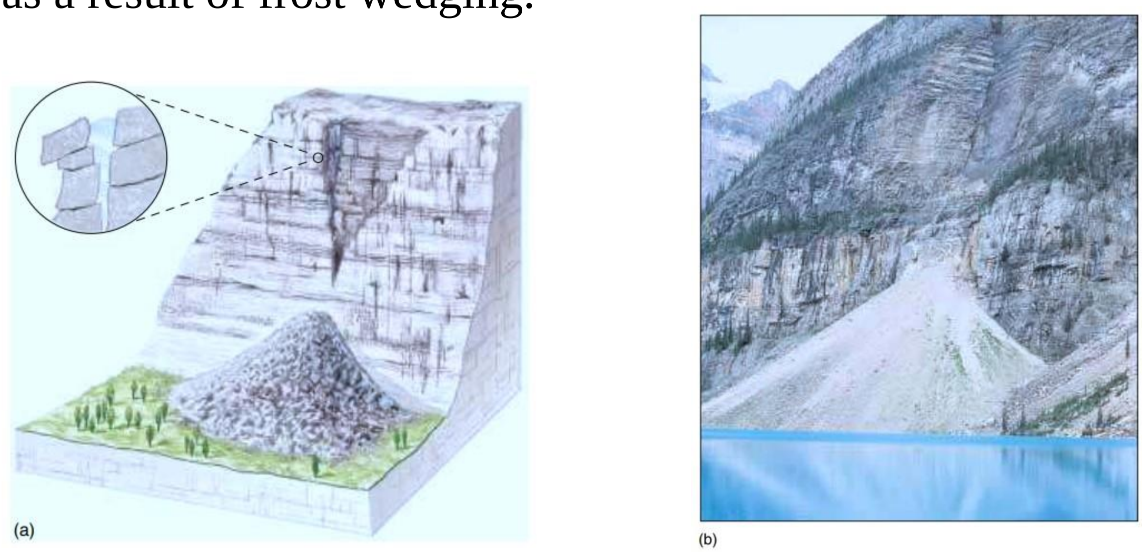
Many igneous and metamorphic rocks form deep below the Earth's surface. Imagine, for example, that a granitic pluton solidifies from magma at a depth of 15 kilometers. At that depth, the pressure from the weight of overlying rock is about 5000 times that at the Earth’s surface. Over millennia, tectonic forces may raise the pluton to form a mountain range. The overlying rock erodes away as the pluton rises and the pressure on the buried rock decreases. As the pressure diminishes, the rock expands, but because the rock is now cool and brittle, it fractures as it expands. This process is called pressure-release fracturing. Many igneous and metamorphic rocks that formed at depth, but now lie at the Earth’s surface, have been fractured in this manner.



Pressure-release fracturing contributed to the formation of these cracks in a granite cliff in Tuolumne Meadows, California.

Frost wedging

Water expands when it freezes. If water accumulates in a crack and then freezes, its expansion pushes the rock apart in a process called frost wedging. In a temperate climate, water may freeze at night and thaw during the day. Ice cements the rock together temporarily, but when it melts, the rock fragments may tumble from a steep cliff. If you hike or climb in mountains when the daily freeze–thaw cycle occurs, be careful; rockfall due to frost wedding is common. Experienced climbers travel in the early morning when the water is still frozen, and ice holds the rock together. Large piles of loose angular rocks, called talus slopes, lie beneath many cliffs. These rocks fell from the cliffs mainly as a result of frost wedging.



(a) Frost wedging dislodges rocks from cliffs and creates talus slopes. (b) Frost wedging has produced this talus cone in Valley of the Ten Peaks, Canadian Rockies.

Abrasion

Many rocks along a stream or beach are rounded and smooth. They have been shaped by collisions with other rocks as they tumbled downstream and with silt and sand carried by moving water. As particles collide, their sharp edges and corners wear away. The mechanical wearing and grinding of rock surfaces by friction and impact is called abrasion. Note that pure water itself is not abrasive; the collisions among rock, sand, and silt cause the weathering.

Wind also hurls sand and other small particles against rocks, often sandblasting unusual and beautiful landforms. Glaciers also cause much abrasion as they drag particles ranging in size from clay to boulders across bedrock. In this case, both the rock fragments embedded in the ice and the bedrock beneath are abraded.

Abrasion rounded these rocks in a streambed in Yellowstone National Park, Wyoming. Wind abrasion selectively eroded the base of this rock in Lago Poopo, Bolivia, because windblown sand moves mostly near the ground surface.

Organic activity

If soil collects in a crack in solid rock, a seed may fall there and sprout. The roots work their way down into the crack, expand, and may eventually push the rock apart. City dwellers often see the results of organic activity in sidewalks, where tree roots push from underneath, raising the concrete and frequently cracking it

As this tree grew from a crack in bedrock, its roots forced the crack to widen.

Thermal expansion and contraction

Rocks at the Earth’s surface is exposed to daily and yearly cycles of heating and cooling. They expand when they are heated and contract when they cool. When temperature changes rapidly, the surface of a rock heats or cools faster than its interior and, as a result, the surface expands or contracts faster than the interior. The resulting forces may fracture the rock.

Chemical weathering

Rock is durable over a single human lifetime. Return to your childhood haunts and you will see that the rock outcrops in woodlands or parks have not changed. Over longer expanses of geologic time, however, rocks decompose chemically at the Earth's surface. The most important processes of chemical weathering are dissolution, hydrolysis, and oxidation. Water, carbon dioxide, acids and bases, and oxygen are common substances that cause these processes to decompose rocks.

Dissolution

If you put a crystal of halite (rock salt) in water, it dissolves, and the ions disperse to form a solution. Halite dissolves so rapidly and completely that this mineral is rare in moist environments. Acids and bases are generally more effective at dissolving minerals than pure water because they provide more electrically charged hydrogen and hydroxyl ions to pull atoms out of crystals. For example, limestone is made of the mineral calcite (CaCO3). Calcite barely dissolves in pure water but is quite soluble in acid. If you place a drop of strong acid on limestone, bubbles of carbon dioxide gas rise from the surface as the calcite dissolves.

Stalactites and stalagmites in a limestone cavern.

Hydrolysis

During dissolution, a mineral dissolves but does not otherwise react chemically with the solution. However, during hydrolysis, water reacts with a mineral to form a new mineral with the water incorporated into its crystal structure. Many common minerals are weathered by hydrolysis. For example, feldspar, the most abundant mineral in the Earth's crust, weathers by hydrolysis to form clay. As feldspar converts to clay, flowing water carries off soluble cations such as potassium. The water combines with the less soluble ions to form clay minerals.

coarse grains of quartz and feldspar accumulate directly over weathered granite. The lens cap in the middle illustrates scale.

Oxidation

Many elements react with atmospheric oxygen, O2. Iron rusts when it reacts with water and oxygen. Rusting is one example of a more general process called oxidation. 2 Oxidation reactions are so common in nature that pure metals are rare in the Earth's crust, and most metallic elements exist in nature as compounds. Only a few metals, such as gold, silver, copper, and platinum commonly occur in their pure states.

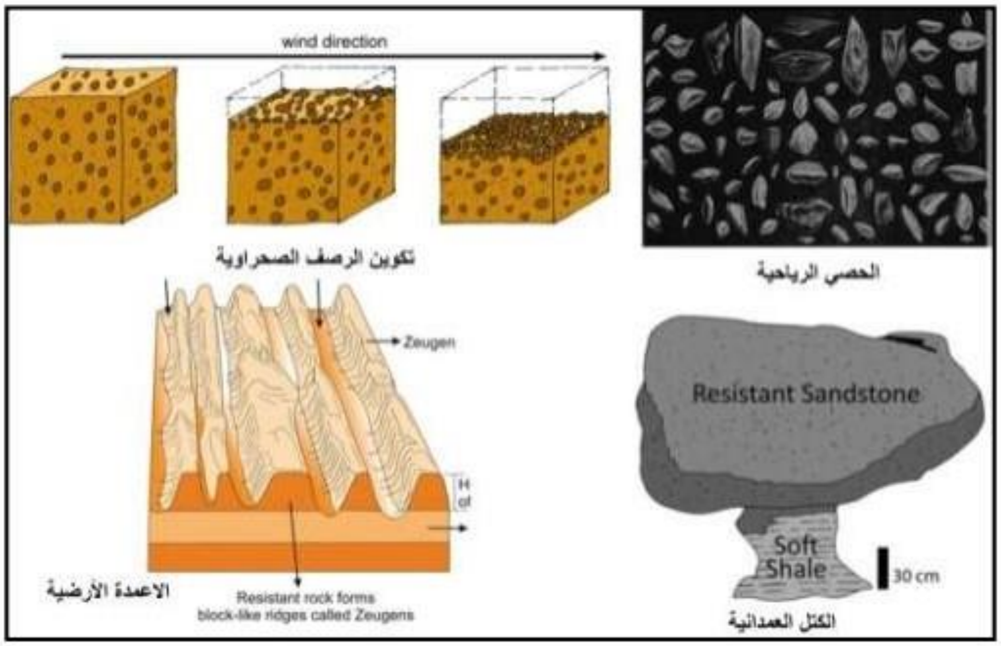
Erosion

Erosion is the geological process in which earthen materials are worn away and transported by natural forces such as wind or water. A similar process, weathering, breaks down or dissolves rock, but does not involve movement. Erosion is the opposite of deposition, the geological process in which earthen materials are deposited, or built up, on a landform. Most erosion is performed by liquid water, wind, or ice (usually in the form of a glacier). If the wind is dusty, or water or glacial ice is muddy, erosion takes place. The brown color indicates that bits of rock and soil are suspended in the fluid (air or water) and being transported from one place to another. This transported material is called sediment.

Erosion by Wind

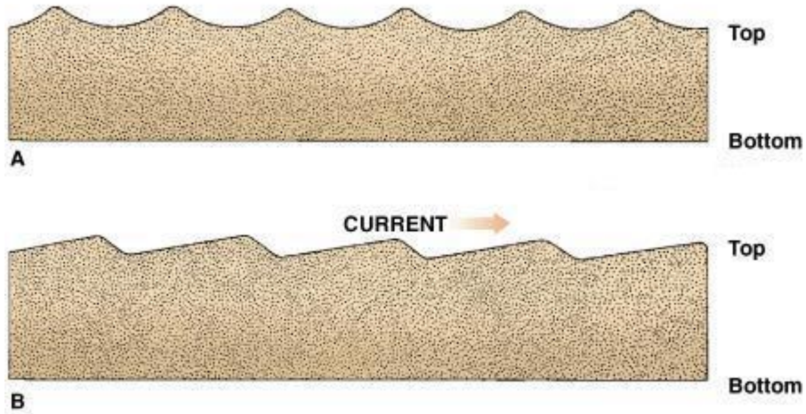
Wind is a powerful agent of erosion. Aeolian (wind-driven) processes constantly transport dust, sand, and ash from one place to another. Wind can sometimes blow sand into towering dunes. Some sand dunes in the Badain Jaran section of the Gobi Desert in China, for example, reach more than 400 meters (1,300 feet) high. In dry areas, windblown sand can blast against a rock with tremendous force, slowly wearing away the soft rock. It polishes rocks and cliffs until they are smooth giving the stone a so-called "desert varnish." Wind is responsible for the eroded features that give Arches National Park, in the U.S. state of Utah, its name.

Wind can also erode material until little remains at all. Ventifacts are rocks that have been sculpted by wind erosion. The enormous chalk formations in the White Desert of Egypt are ventifacts carved by thousands of years of wind roaring through the flat landscape. Some of the most destructive examples of wind erosion are the dust storms that characterized the "Dust Bowl" of the 1930s in North America. Made brittle by years of drought and agricultural mismanagement, millions of tons of valuable topsoil were eroded away by strong winds in what came to be known as “black blizzards.” These dust storms devastated local economies, forcing thousands of people who depended on agriculture for their livelihoods to migrate.

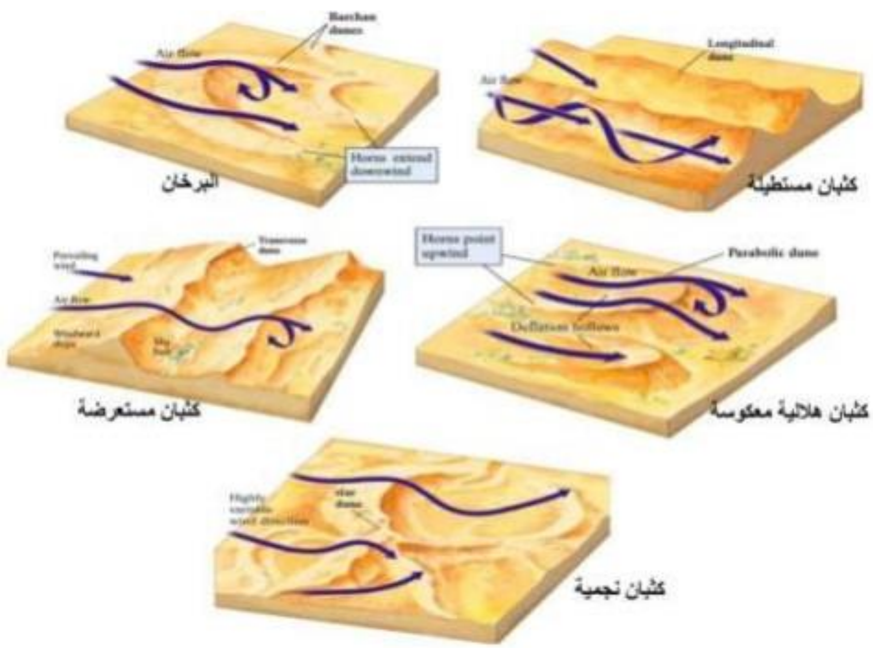


Geological features are produced by erosion of wind.

As for the structural work of the wind, it occurs as soon as these winds encounter obstacles or protrusions that lead to stopping them or reducing their speed, throwing the sand and dust they carry, and depositing these in the form of ripples or dunes.



Ripple marks



Sand dunes

<u>Rain Erosion</u>

Rainfall is frequent in the tropics and gradually decreases towards the poles, and the amount of rain in the coastal regions is greater than within the continents. When rainwater descends on the ground, we find that some of it evaporates again and rises in the air, while another part seeps into the pores, holes and cracks of rocks and reaches varying depths from the surface of the earth, forming what is known as groundwater.

The third part flows on the surface of the earth, forming what is known as running water, such as rivers. The rain has only destructive work, and the structural work is not done, which is the sedimentation of the rocky crumbs carried by these rains, except by rivers and groundwater, which is what rainwater leads to. That is, rain only acts as demolition and transportation while running water completes this process and eventually sedimentation.

Torrent Erosion

When heavy rains fall on the hills or mountains, their waters descend into narrow streams and then connect these groups of rainwater streams and be torrents and the torrent grow and increases in size and increases its speed until it reaches a river that flows into it, such as torrents that descend from the top of the Red Sea mountains in the eastern desert and flow into the Nile Valley.

Torrents sweep the mud materials, gravel of various sizes or large rock masses on their way if the torrent is sweeping and strong. These materials are like machines used by torrents in carving and deepening their streams and over the years we find that the narrow sewers that arise at the beginning from the carving of torrents have turned into very narrow canyons (Canyons) It has been found that the destructive work of torrents appears clearly in the deserts for the scarcity of the presence of plants in them, unlike its impact in the countries that Covered by vegetation and forests.

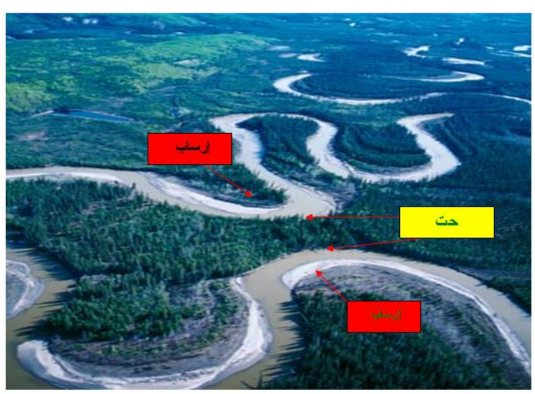
When the torrential water comes out of its canyons, it spreads on the surfaces of the plains, thus losing its speed and starting to deposit the materials it carries. The sedimentation is usually either in the form of a semicircle centered at the exit of the creek and is called what is deposited as the cone of torrents (Alluvial cone) or the sedimentation is in the form of a triangle whose top is at the exit of the creek where the rocky masses and large gravel are deposited and then the size of the gravel gradually decreases and ends with sand and clay materials at the base of the triangle and this type of sedimentation is known as dry functions

Alluvial cone

River Erosion

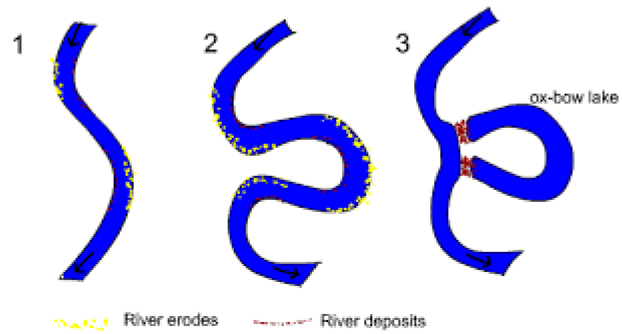
Rivers differ from torrents in that the water in them is sustainable because they start in areas with a lot of rain or areas covered by snow, as well as they depend on what flows into them from tributaries, springs and lakes, and often the course of the river is steep in the part near its source and a little steep in the lower part of it or near its mouth.

The destructive work of the rivers includes the impact on the sides of the river course and its bottom, so it helps it with the materials it carries, and this effect varies according to the speed of the current and the volume and nature of the water The amount of material carried in the water and the nature of the rocks that make up the riverbed itself. The charge or load of a river includes substances dissolved in its waters such as salts such as calcium carbonate, magnesium carbonate and sodium chloride (table salt). This load also includes materials suspended in the water, which is due to the difference in the speed of the current, so we find it is greater in the middle of the river than at its sides or near the bottom - and the speed increases with the presence of slopes in the course of the valley and the difference in the speed of the current leads to the presence of vortices that cause the rock crumbs to be lifted from the bottom and carried suspended in the water. We add that the tonnage of the river is not limited to the two types mentioned above, but also includes the masses.



Each river has a cycle that includes the different changes that occur to it, and this cycle includes three stages: youth, maturity, and aging. In the youth stage, the digging of streams, branches and valleys is most intense, and the rivers are fast and have an irregular slope, so lakes, watersheds and canyons are formed. At this stage, the phenomenon of river capture abounds. It is a phenomenon that arises from the ability of one branch to carve more than the other branch, so its course becomes lower, so the water of the other branch flows in this branch and thus the sculpture stops in the course of the other river. This youth stage comes to an end when the watercourse becomes graded, when lakes, waterfalls or waterfalls disappear, and the canyons expand into valleys.

As for the maturity stage, the valley expands to its maximum extent and becomes an open V-shape, and the river is said to be middle-aged, and there are many meanders or river twists at this stage, as well as arc lakes.



In the aging stage (Old stage) decreases the ruggedness of the valley and decreases the slope of the river and the river loses its ability to carve and begins to sedimentation as the speed of its current weakens and the land area to which the riverbed is called the flat plain (Peneplain) and the river becomes old or old. All of these stages can be found in one river or in separate parts of it. The older the river, the higher the aging or sedimentation stage in its proportion over the other two stages.

12. Geological or Tectonic structures

Structural geology: is the branch of geology concerned with the shapes, arrangement, and geometries of bedrock units in the earth crust and the forces that cause them. A geologic structure is a geometric feature in rock whose shape, form, and distribution can be described. Depending how they formed, geologic structures are classified into:

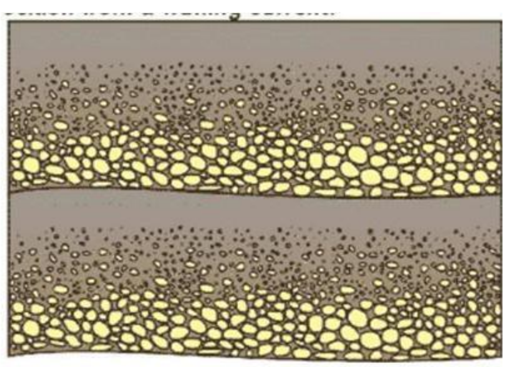
- Primary structures
- Secondary structures

Primary structure

- Bedding (Stratification):
  - when layers of sediments are deposited on top of each other
  - A bed is a unit of sediments that have an upper and lower surface.
  - The bed's thickness ranges from 1 cm to several meter.
  - A bed thinner than 1 cm is called a lamina.

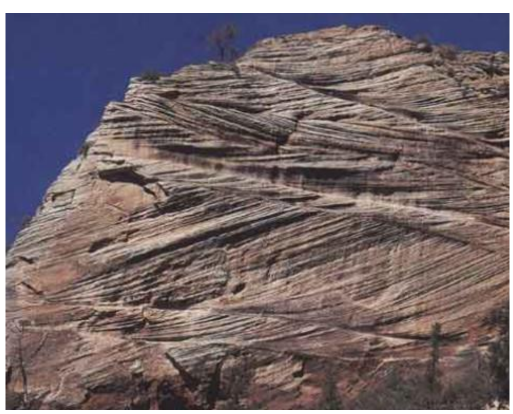
 

Graded bedding: Change in grain size within the bed from coarse grains at the bottom to fine grains at the top.

Graded bedding

Cross bedding

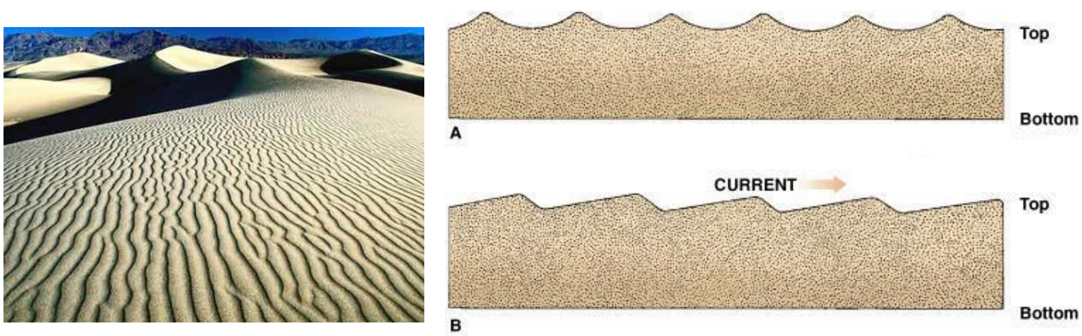


Ripple marks

Wavy structures formed on the surface of a rock by water or wind action:

Symmetrical ripple marks: created by water currents.

Asymmetrical ripple marks: Created by winds in a desert.



Ripple marks

Mud cracks

Formed in clay-bearing soils as a result of drying by sun and losing of water content.

Mud -cracks

Secondary structures

Develop in rocks after their formation as a result of their subjection to external forces.

1- Folds

- when originally horizontal layers, are bent or curved as a result of deformation.
- They are formed by horizontal stress or by vertical stress.

Fold components

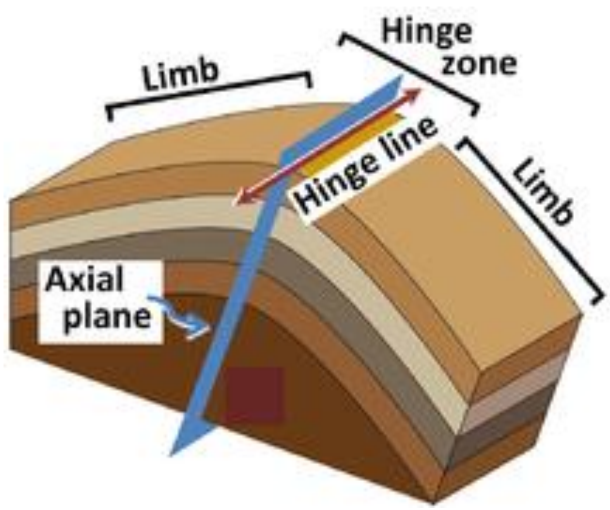
Hing line: The line of maximum curvature

Limbs: the flanks of the fold

Crest: the highest point of the fold surface

Trough: is the lowest point

The axial plane (or the axial surface): The axial plane can be defined as the plane or surface that divides the fold as symmetrically as possible.

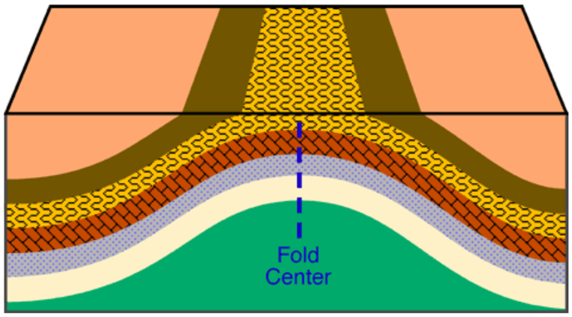


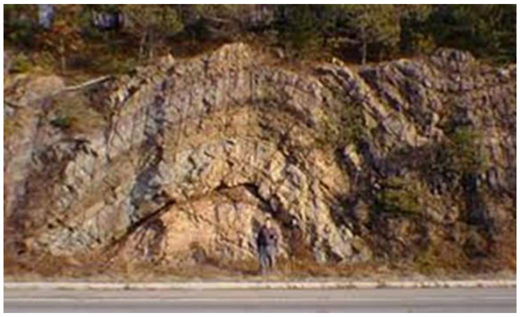
Classification of folds

Basically, there are two types of folds, anticline, and syncline.

1- Anticline fold

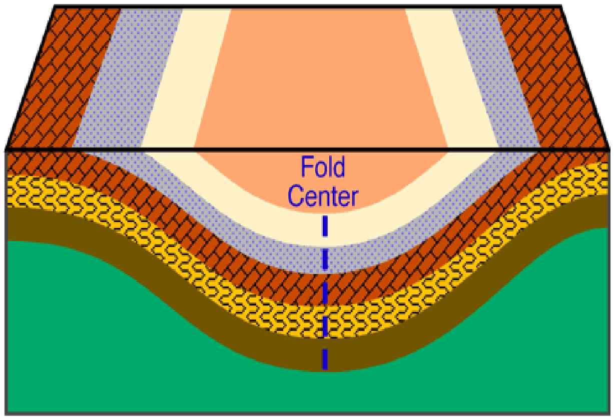
- Consists of beds bent upwards with limbs dipping away from each other.
- The older bed is in the center.

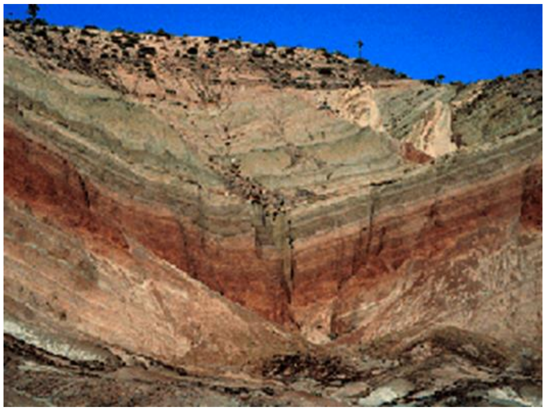




2- Syncline fold

- Consists of beds bent downwards with limbs dipping towards each other.
- The younger bed is in the center.

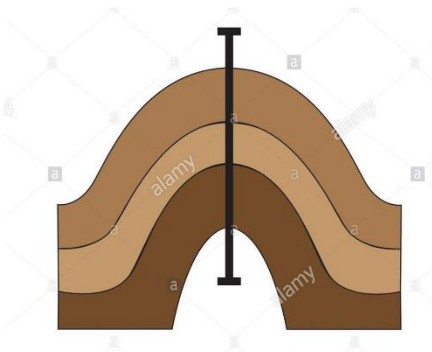




Classification of folds based on axial plane.

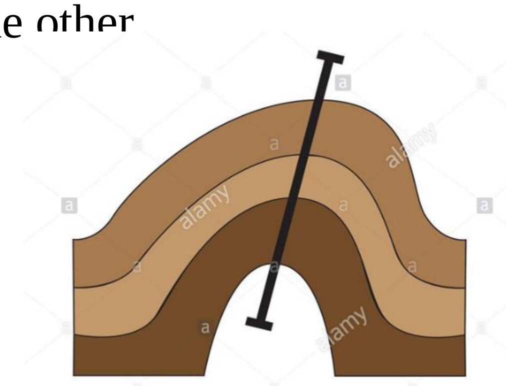
a- Symmetrical folds

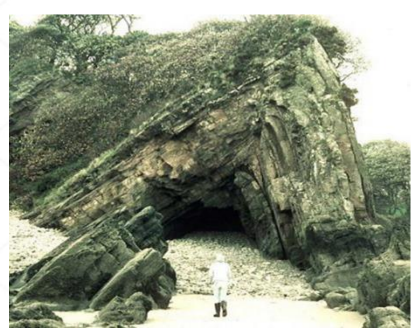
- The axial plane is vertical and the limbs dip equally.
- The axial plane divides the fold into two equal halves.
- Formed when compression from opposite sides is equal.



b- Asymmetrical fold

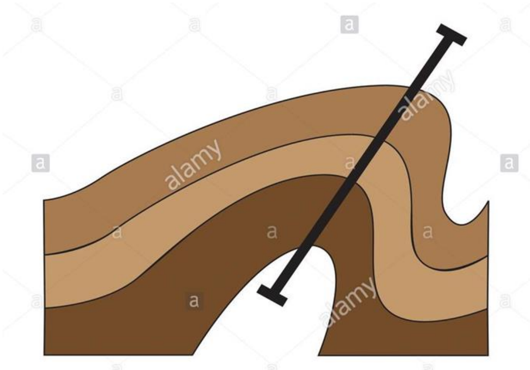
- The axial plane is tilted and the limbs dip at different angles.
- Formed when compression is greater from one side than the other

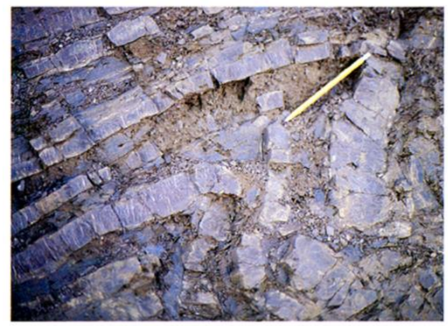




c- Overturned (overfold) fold.

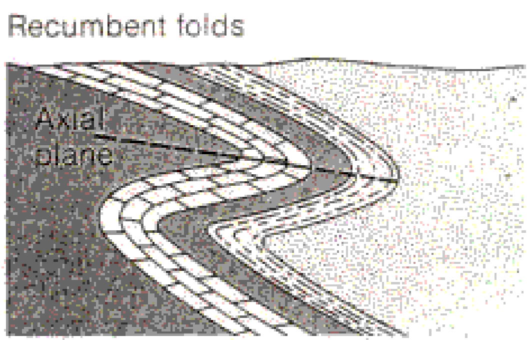
- Formed when one-fold is pushed over the other limb due to increasing compression
- Both limbs are sloping in the same direction





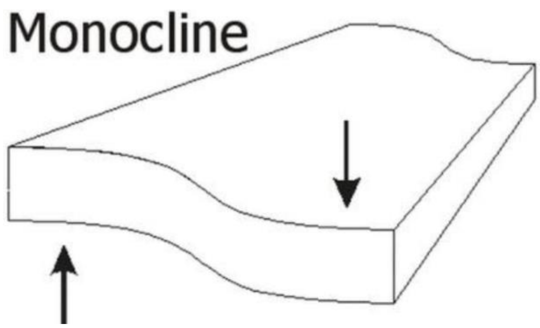
d- Recumbent fold

- Formed when the axial plane is almost horizontal
- The limbs are nearly parallel to each other.
- Formed the compression highly increased on one side



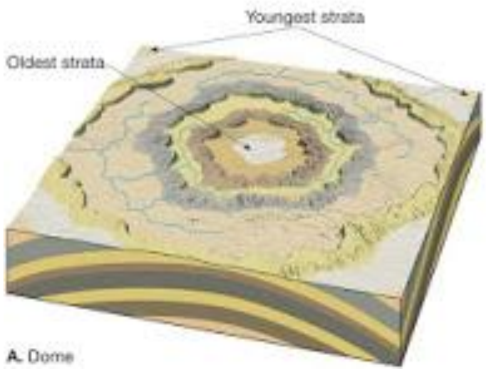
e- Monocline fold

One only limb is bent – no axial plane is formed.



f- Dome fold

- An anticline fold where the beds bend outside in all directions.
- The fold has a semi-circular shape formed by vertical compression.
- Older rocks were found in the center.

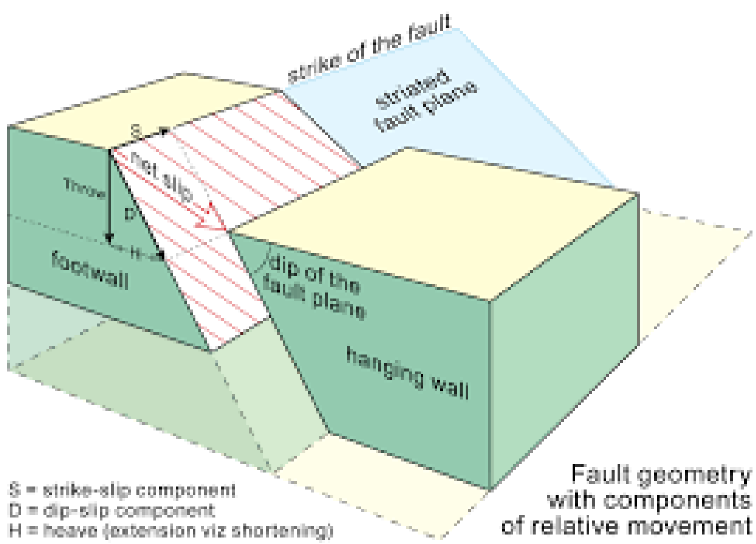


Faults

Faults are fractures in bedrock along which movement has occurred. They are formed by compression or tension.

Fault components

- Fault plane: is the fracture surface of a fault
- Hanging wall: The body of rock above the fault
- Foot wall: the body of rock below the fault
- Fault throw (displacement or slip): is the vertical component of displacement.
- Heave: the horizontal component of displacement
- Dip (or inclination) of a fault: The angle of the fault plane with the horizontal plane.



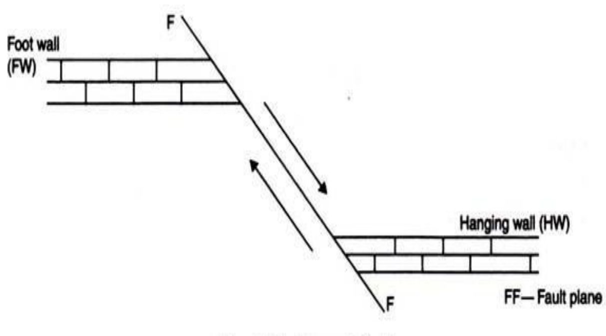
Type of faults

Based on direction of displacement and movement along the fault plane, there are three main types of faults:

Normal Faults - Reverse faults - Transform faults.

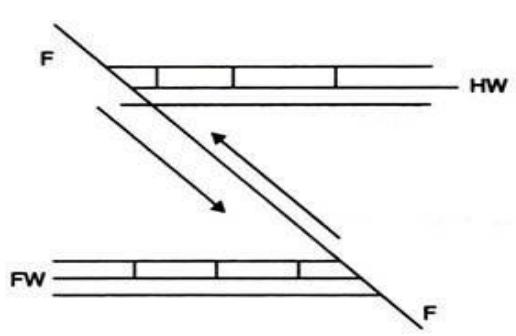
1-Normal fault

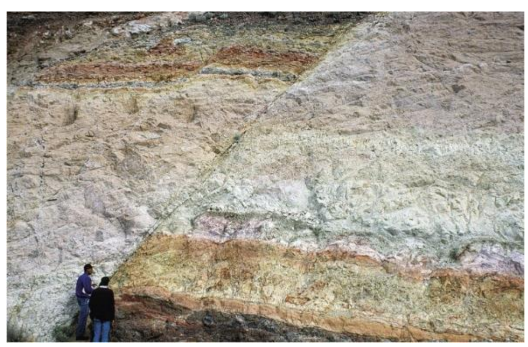
Formed by tension force- rocks move downward – the plane dips in the same direction of movements.



2-Reverse fault

Formed by compression- rocks move upward- dips on opposite direction of movements.





3-Transform fault

Rocks move horizontally to each other, formed by horizontal compression.

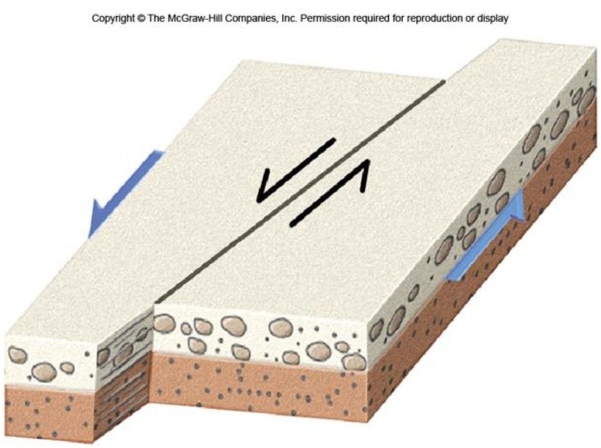
Types:

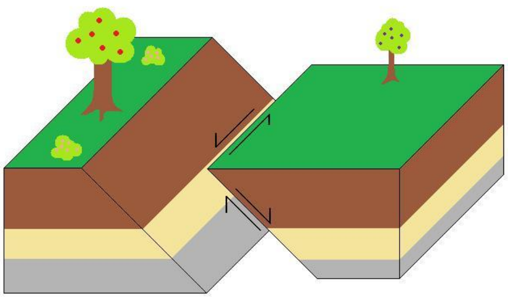
Transform faults:

Rock slips horizontally

Oblique-slip faults:

movement with both vertical and horizontal components





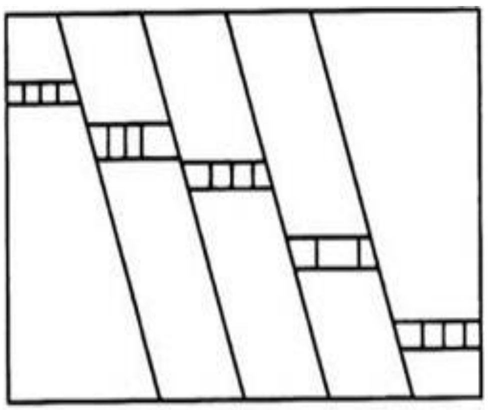
Oblique-slip fault: Arrows represent relative movement.

<u>Composite faults</u>

1-step faults

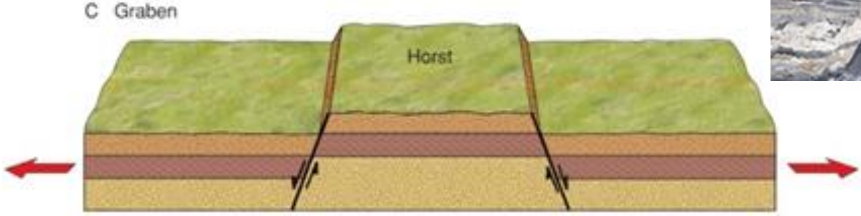
A series of parallel faults that all inclined in the same direction.

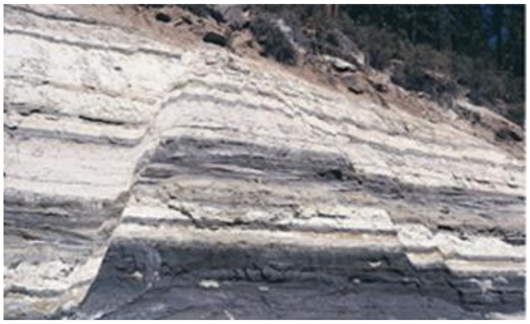
downthrown of all is in the same direction and it gives a step-like arrangement.



2. Horsts:

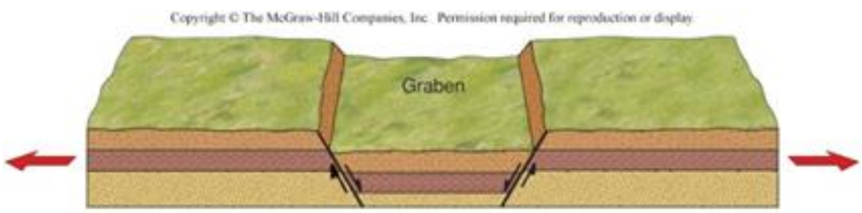
When a rock block pushed upward relative to the blocks on either side by the two normal faults





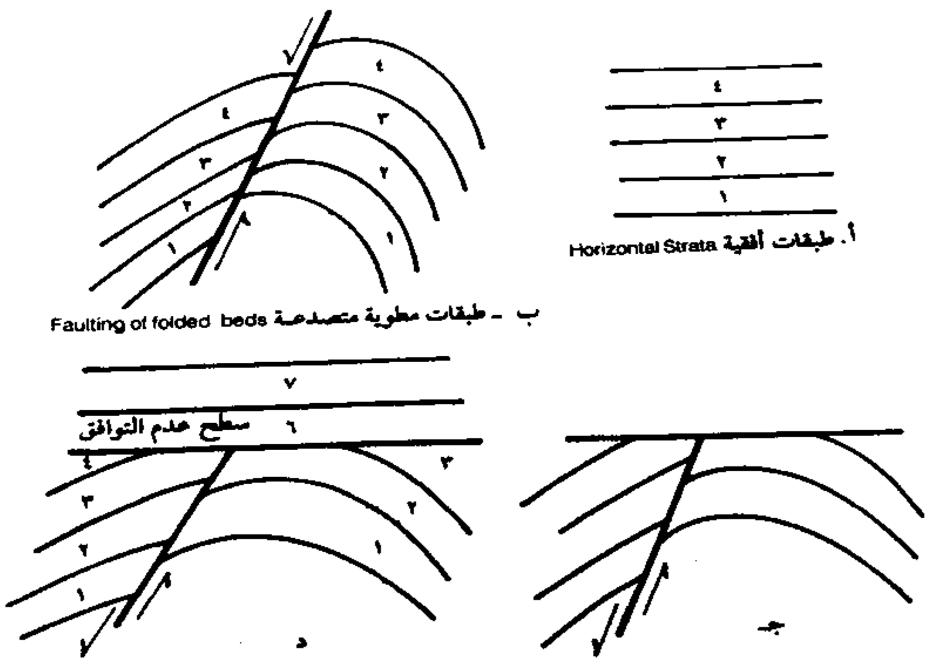
3. Graben:

When a rock block lowered relative to the blocks on either side by two normal faults.



Conformity and unconformity

When the sedimentation basin rises above sea level and as a result of ground movements, the layers tilt, bend or crack, and after that, these raised layers are exposed to erosion factors, and parts of the upper layers are removed, and then they land, forming a new sedimentation basin on which a group of modern layers are deposited above the erosion surface, and thus we have two groups, a group of old layers affected by ground movements, and a group of modern layers separated by a surface of unconformity.



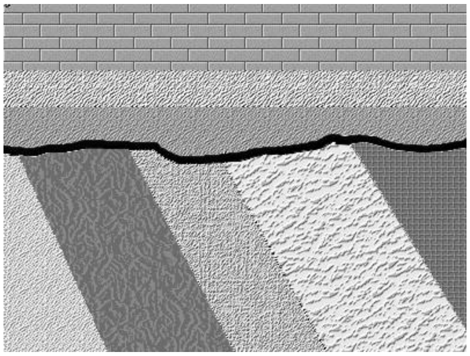
Developments of unconformity

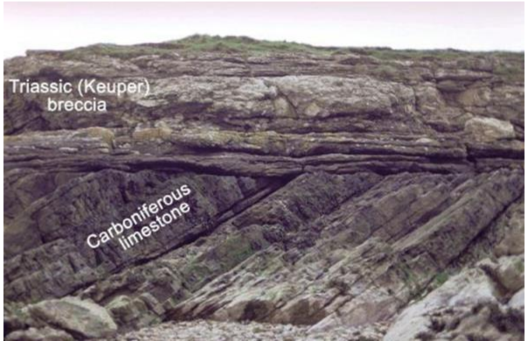
Unconformity can be defined as is a buried erosional or non-depositional surface separating two strata of different ages. Indicating break in the sedimentary geologic record

<u>Types of unconformity</u>

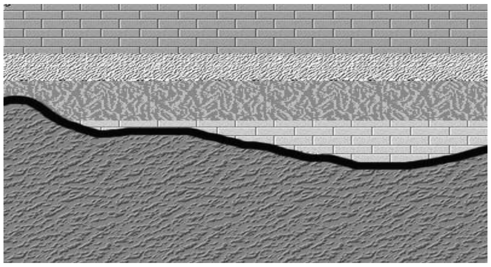
a- Angular unconformity

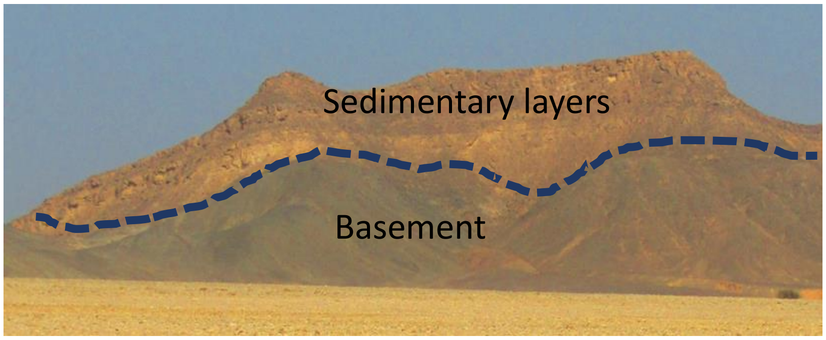
horizontally parallel strata of sedimentary rock are deposited on tilted and eroded layers.





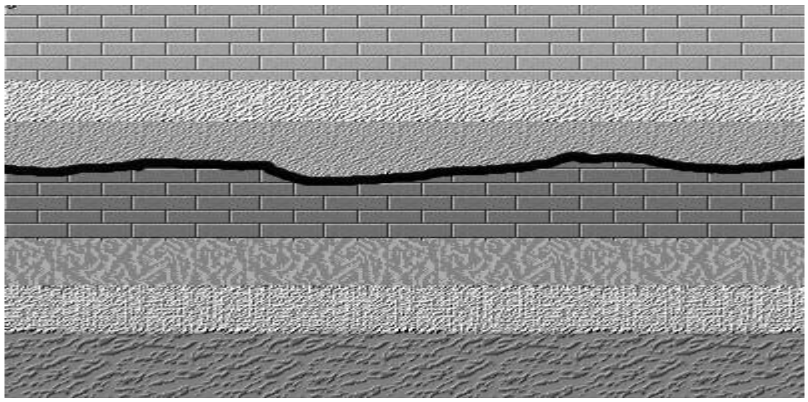
Exists between the younger sedimentary rocks and older metamorphic or igneous rocks. the sedimentary rock lies above the pre-existing and eroded metamorphic or igneous rock





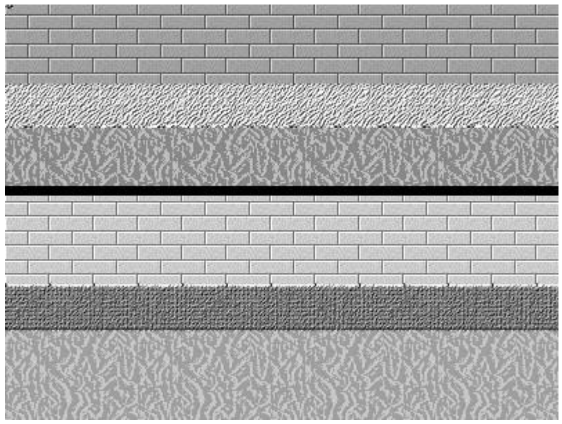
c- Disconformity

Formed between parallel layers of sedimentary rocks which represents a period of erosion or non-deposition.



d- Para - conformity

In which the two rock groups are in an almost horizontal position or have the same degree of inclination in the same direction and is also called false conformity (since the geologist may be deceived in determining the surface of the unconformity) and the layers can be distinguished by its fossil content



13. References

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