## What is Geology?

geology is the study of Earth—its interior and its exterior surface, the minerals, rocks, and other materials that are around us, the processes that have resulted in the formation of those materials, the water that flows over the surface and through the ground, the changes that have taken place over the vastness of geological time, and the changes that we can anticipate will take place in the near future. Geology is a science, meaning that we use deductive reasoning and scientific methods to understand geological problems.

## Why Study Geology (Earth)?

The simple answer to this question is that Earth is our home—our only home for the foreseeable future—and in order to ensure that it continues to be a great place to live, we need to understand how it works. Another answer is that some of us can't help but study it because it's fascinating. But there is more to it than that:

1- We rely on Earth for valuable resources such as soil, water, metals, industrial minerals, and energy, and we need to know how to find these resources and exploit them sustainably.
2- We can study rocks and the fossils they contain to understand the evolution of our environment and the life within it.
3- We can learn to minimize our risks from earthquakes, volcanoes, slope failures, and damaging storms.
4- We can learn how and why Earth's climate has changed naturally in the past, and use that knowledge to understand both natural and human-caused climate change.
5- We can use our knowledge of Earth to understand other planets in our solar system, as well as those around distant stars.

## What Do Geologists Do?

Geologists are involved in a range of widely varying occupations with one thing in common: the privilege and responsibility of studying this fascinating planet. many geologists work in the resource industries, including mineral exploration and mining and energy exploration and extraction. Other major areas where geologists work include hazard assessment and mitigation (e.g., assessment of risks from slope failures, earthquakes, and volcanic eruptions); water supply planning, development, and management; waste management; and assessment of geological issues in the forest industry, and on construction projects such as highways, tunnels, and bridges.

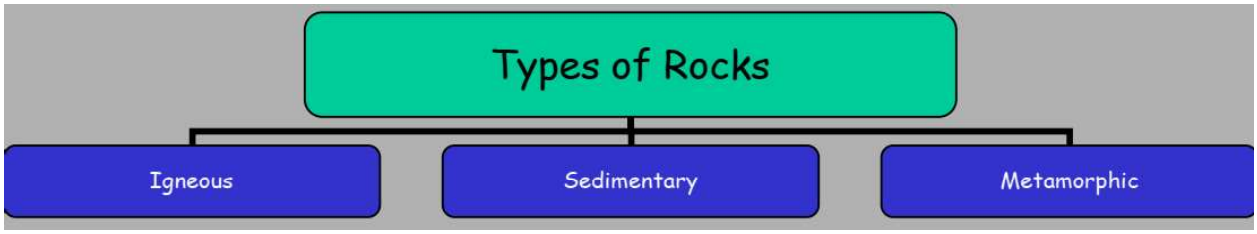
## What is a rock?




## Classification of rocks:

The three main types, or classes, of rock are:

1. Igneous
2. Sedimentary
3. Metamorphic

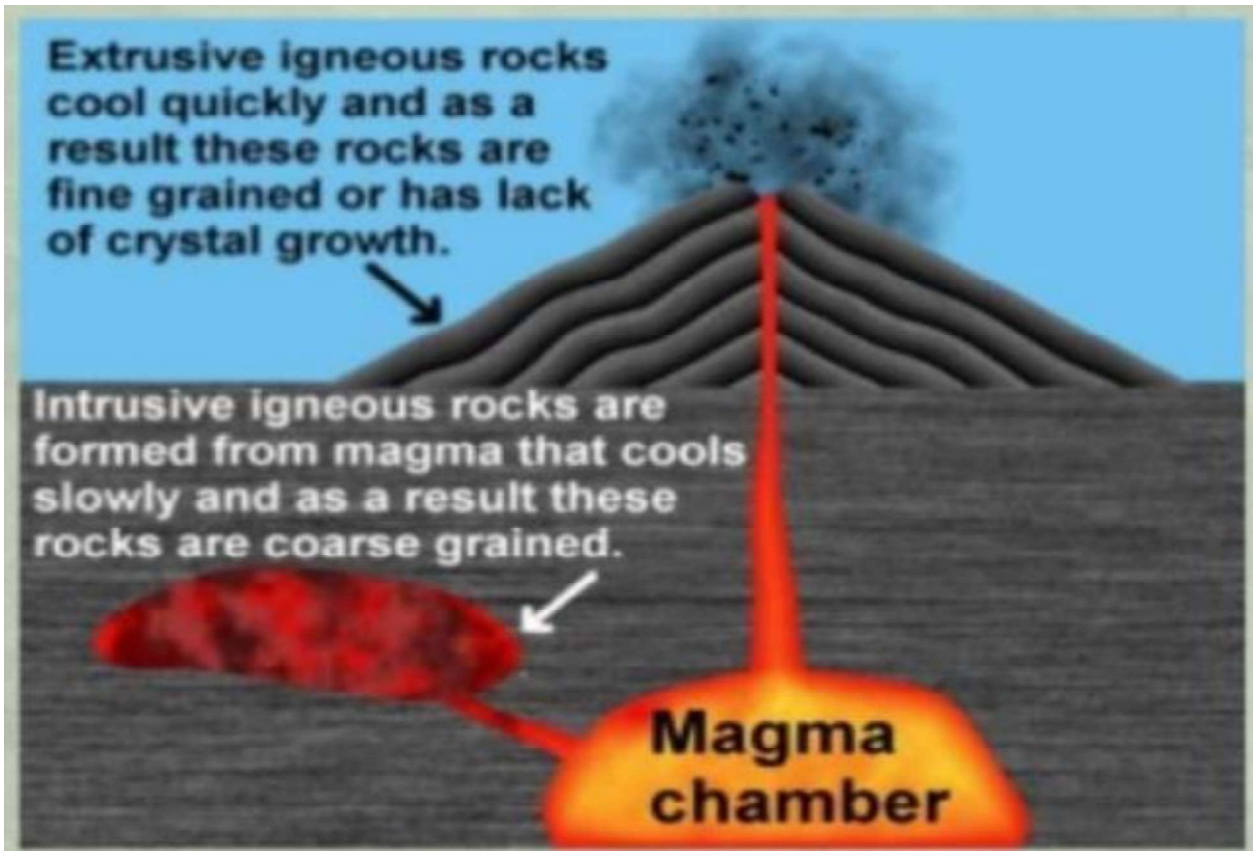



**1. Igneous rocks** are formed from liquid molten rock that cool slowly and harden.
**Igneous** means made from fire and heat.

**Classification of igneous rocks two types:**

Extrusive igneous rocks are formed from lava expelled during volcanic eruption. They cool and harden on the earth's surface.

- Intrusive igneous rocks are formed from magma which cool or harden slowly inside the earth.

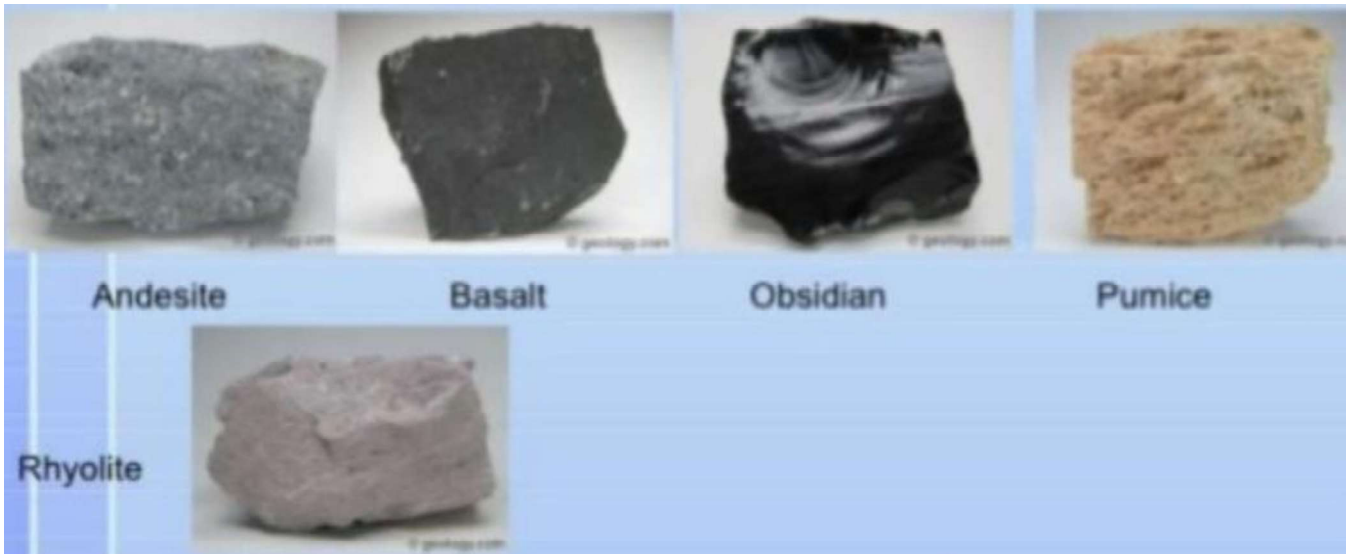


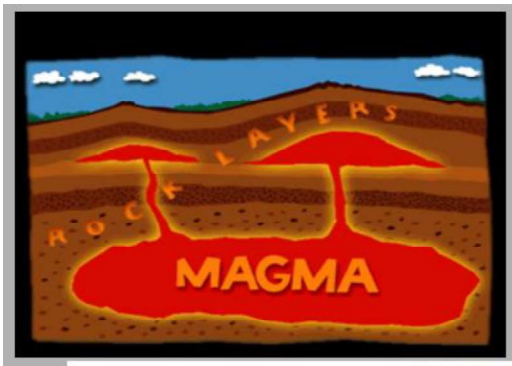
**Difference between Extrusive and Intrusive Igneous rocks:**

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

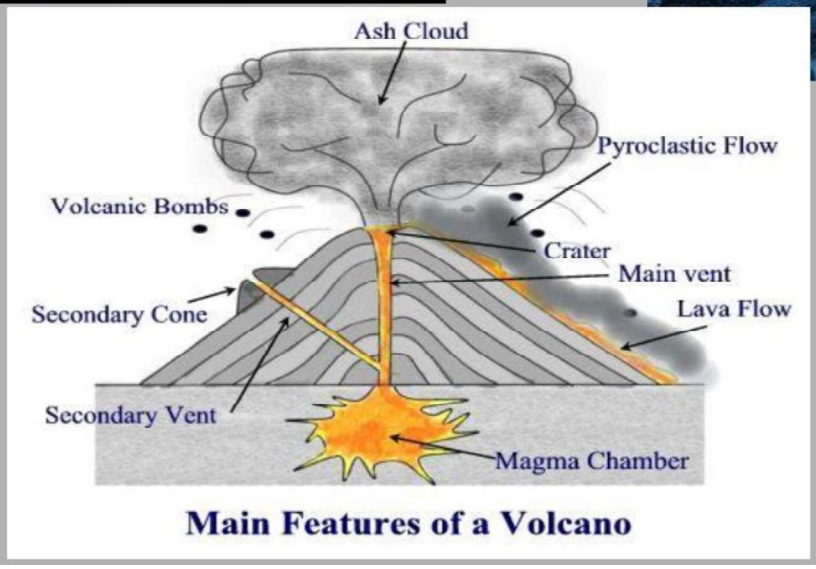



- Extrusive igneous rocks
- Formed from lava "exiting" the volcano and cooling quickly
- Forms fine-grain crystals






**Main Features of a Volcano**

2. **Sedimentary rocks** are formed from sediments such as sand, pebbles, mud, shells and remains of dead plants and animals. They hardened into rock due to pressure of water and weight of more sediments.

**The three main types, or classes, of sedimentary rock are:**

1- Clastic rocks
2- Chemical rocks
3- Organic rocks

**1- Clastic Rocks:** formed from broken fragments cemented together and include the sediments: sand, silt, clay, pebbles, and boulders.




**2- Chemical rocks:** formed when minerals solidify from a solution like seawater or lake water.






**3- Organic rocks**: formed from remains of plants and animals remains.



Limestone-

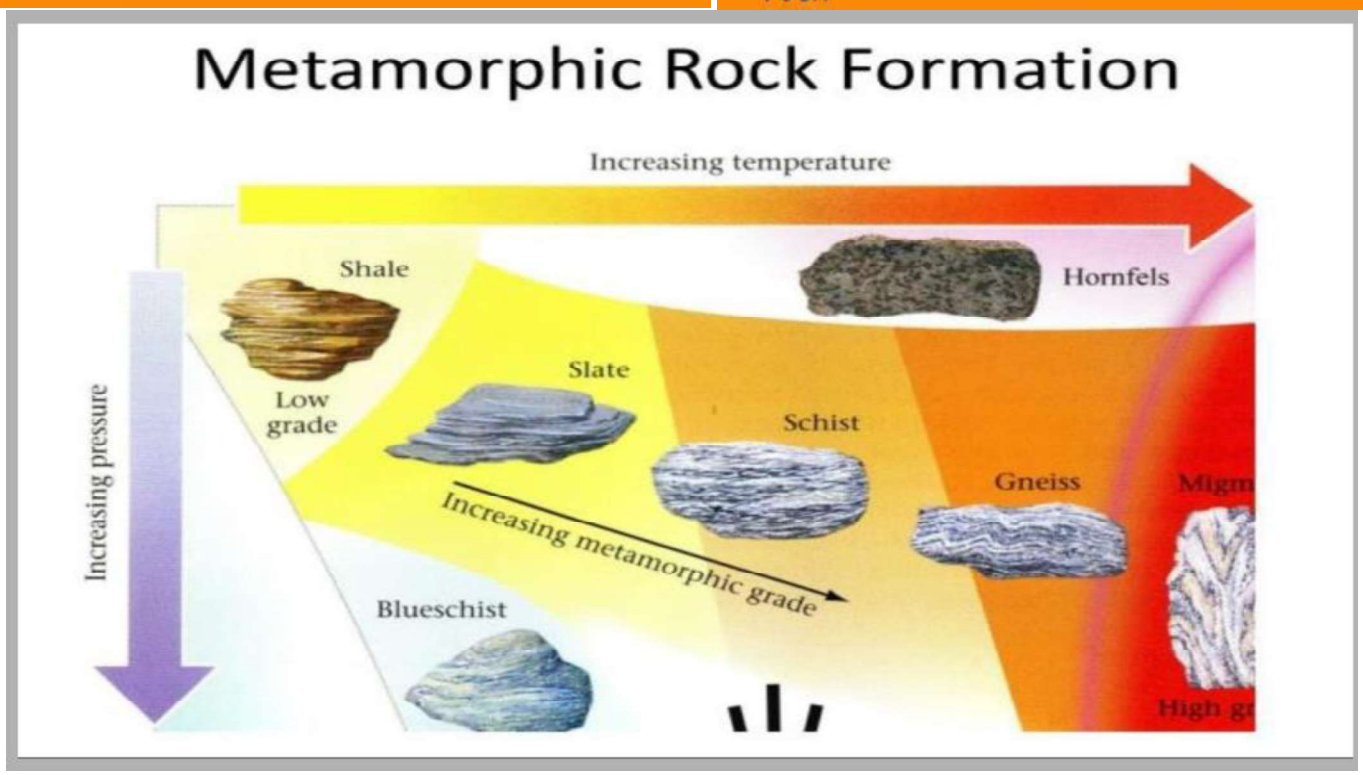


Bituminous

**3-Metamorphic rocks:** rocks that have "morphed" into another kind of rock. These rocks were once igneous or sedimentary rocks. The rocks are under tons and tons of pressure, which fosters heat buildup, and this causes them to change.

**metamorphic rock**- rock that has been changed by temperature and pressure

Rocks inside the Earth soften from Earth's high temperature.
Pressure inside Earth then squeezes the rock. The rock



**There are two types of metamorphic rocks:**

1- Foliated
2- Non-foliated

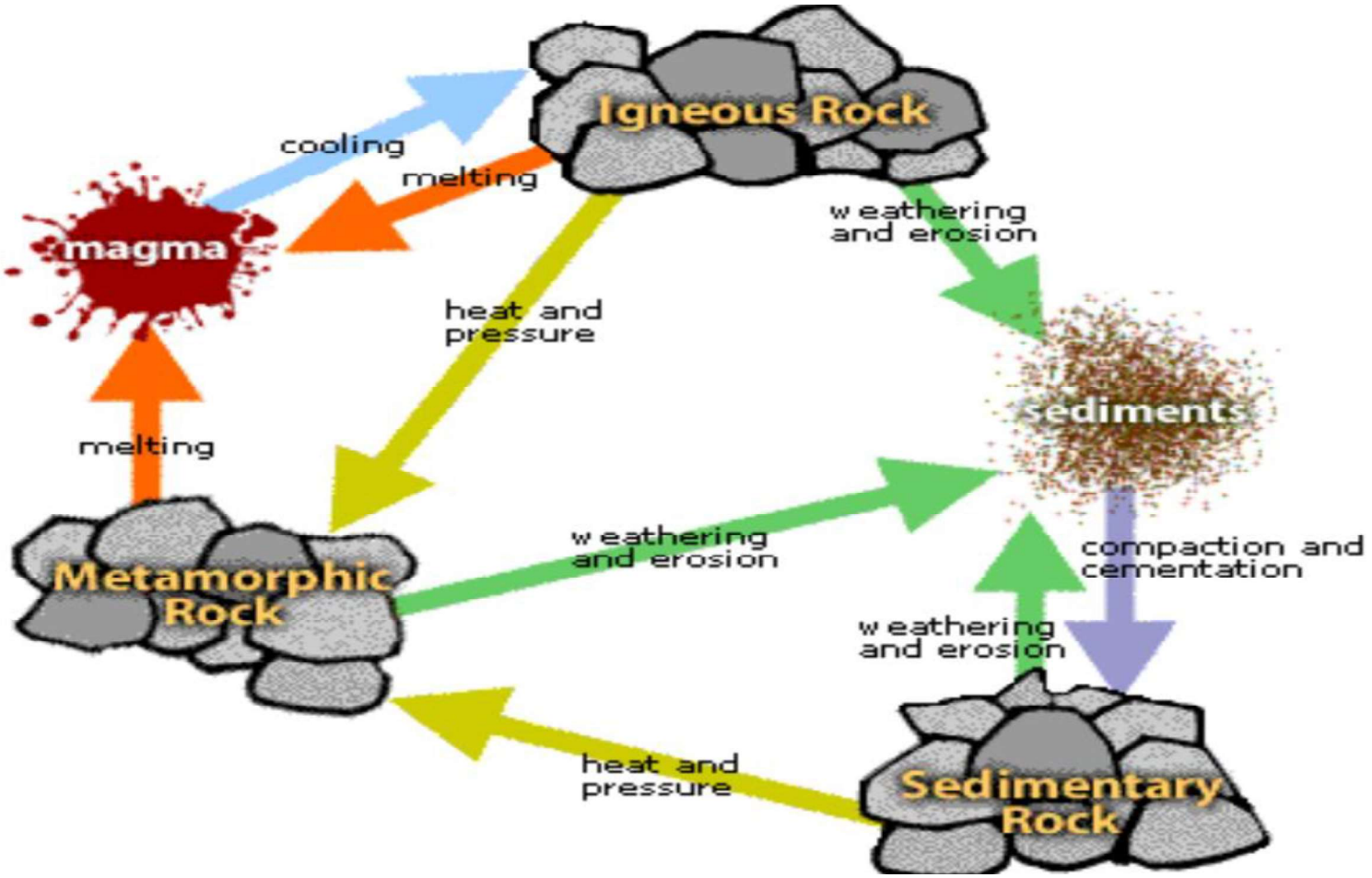
Holey schist



# Rock Cycle

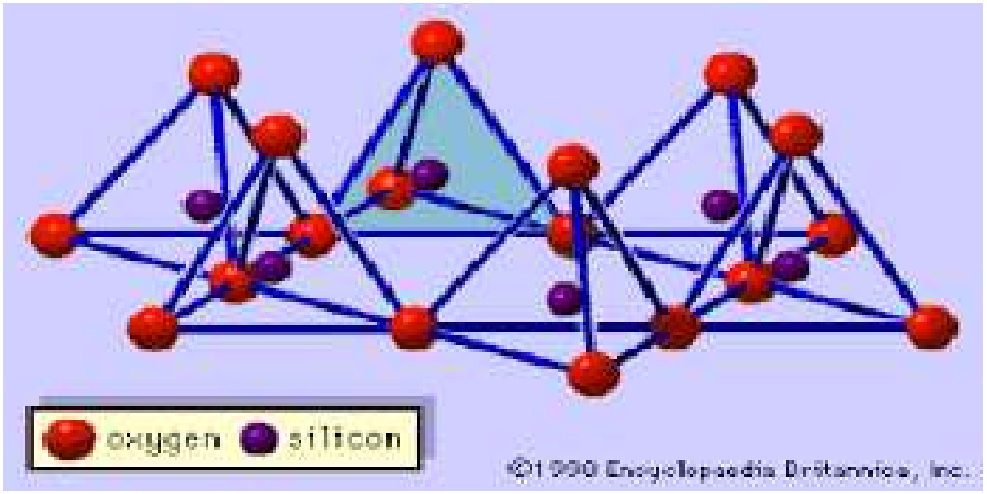
- Rock must go through **melting and solidification** to become an igneous rock
- Rock must go through **weathering and erosion** to become sedimentary rock
- Rock must go through **heat and pressure** to become a metamorphic rock

# Rock Cycle in Earth's Crust



# Clay Minerals المعادن الطينية

Clay minerals are the characteristic minerals of the earths near surface environments. They form in soils and sediments, and by digenetic and hydrothermal alteration of rocks. Water is essential for clay mineral formation and most clay minerals are described as hydrous alumina silicates.

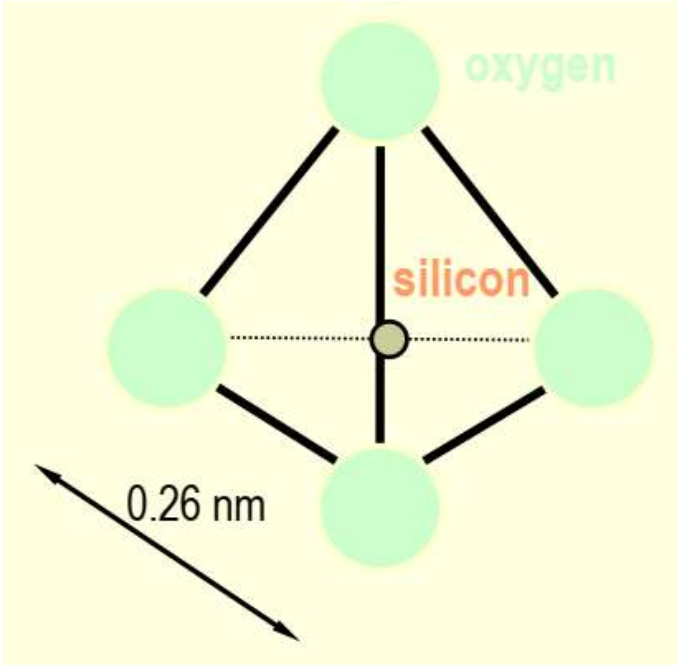



معادن الطين هي المعادن المميزة للأرض بالقرب من البيئات السطحية. تتشكل في التربة والرواسب ، وعن طريق التغيير الجيني والحراري المائي للصخور. الماء ضروري لتكوين المعادن الطينية وتوصف معظم المعادن الطينية بأنها سيليكات الألومينا المائية

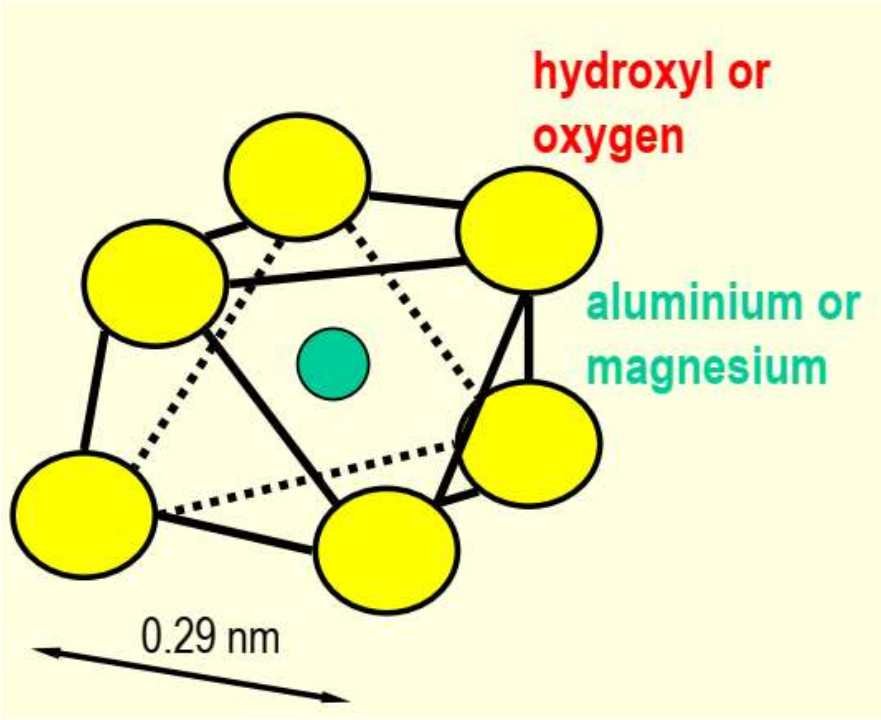
# Basic Structural Units

Clay minerals are made of two distinct structural units.

1- Silicon tetrahedron




2- Aluminum Octahedron

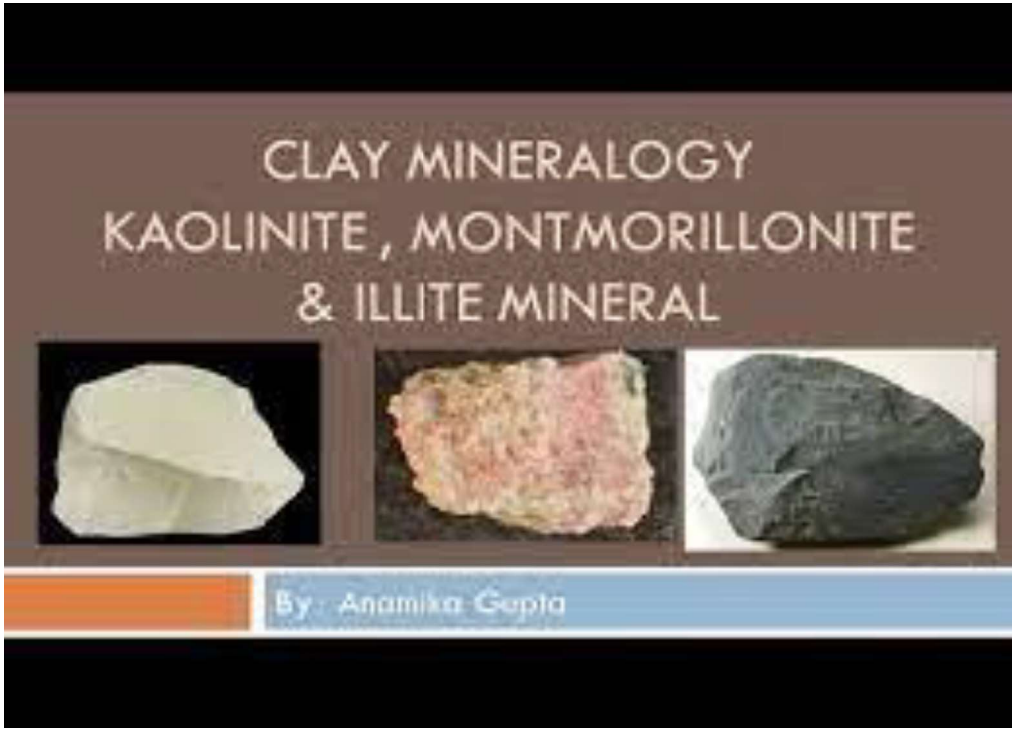


## Type of Clay Minerals:

1- Kaolinite group

2- Montmorillonite group

3- Illite group



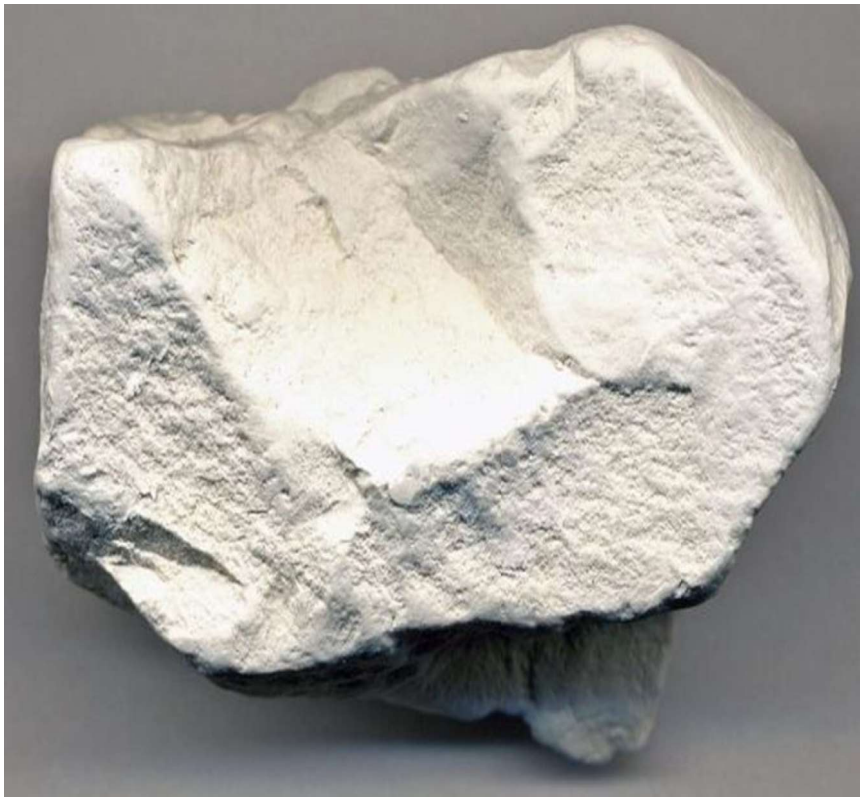
# 1- Kaolinite

Kaolinite is a type of clay mineral having the chemical composition $Al_2SiO_2O_5(OH)_4$. It is a group of industrial minerals that occurs as a layered silicate mineral with one tetrahedral sheet of silica that is linked through oxygen atoms to another octahedral sheet of alumina. Usually, the term kaolin is used to refer to rocks that are rich in kaolinite. China clay is another name for this type of rocks.



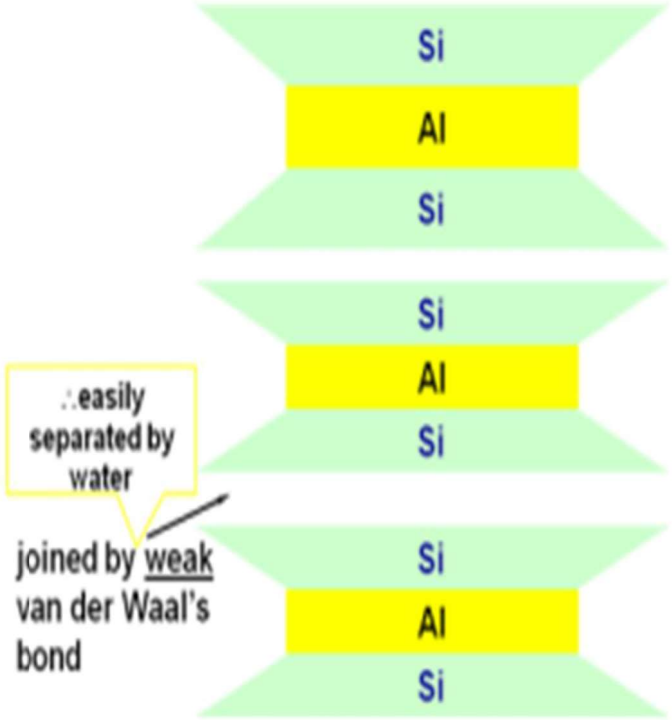
Kaolinite has several important properties, such as low shrink swell capacity and low cation exchange capacity. Also, this mineral is a soft, earthy mineral that is usually white colored. Kaolinite is formed from the weathering of aluminum silicate minerals such as feldspar.

There are many different uses of kaolinite mineral such as the production of paper, ceramics, toothpaste, cosmetics, production of insulating materials such as kaowool, paints, for modification of the properties of rubber upon vulcanization, in organic farming as a spray, etc.



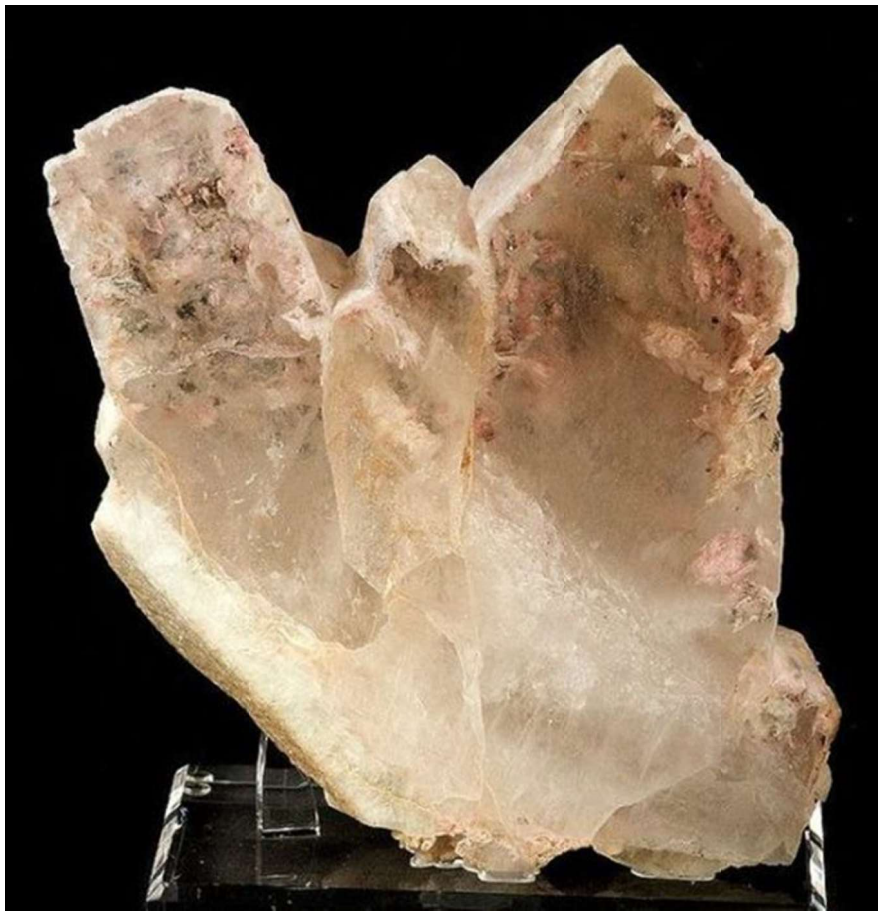
# 2- Montmorillonite

Montmorillonite is a type of clay mineral that has the general formula $(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2.nH_2O$. This mineral belongs to the group of phyllosilicates. The appearance can be described as white, pale pink to red. The fracture of this mineral is uneven. The lustre is dull and earthy. When considering the chemical structure, this material has two tetrahedral sheets of silica, sandwiching a central octahedral sheet of alumina.



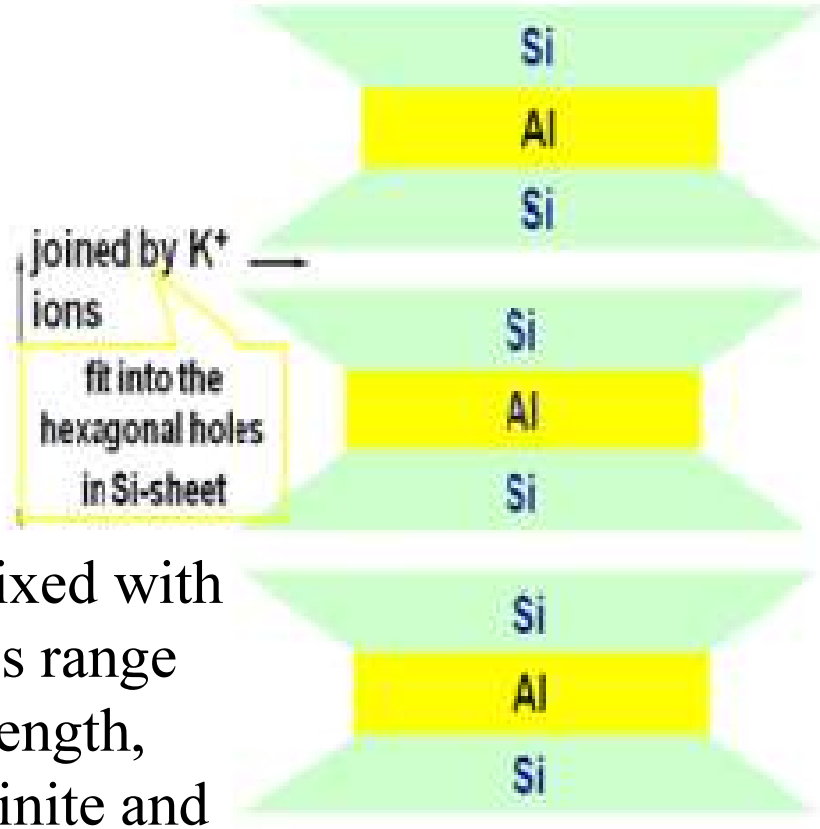

Montmorilloite also called Smectite

There are different uses of montmorillonite. It is used in the dilling industry as a component of drilling mud which helps to make the mud slurry viscous. Also, this material is useful as a soil additive to hold soil water in drought-prone soils. This mineral is very useful in catalytic processes such as catalytic cracking. In addition to that, montmorillonite has a swelling property which makes it important as an annular seal or plug for water wells and as a protective liner for landfills.

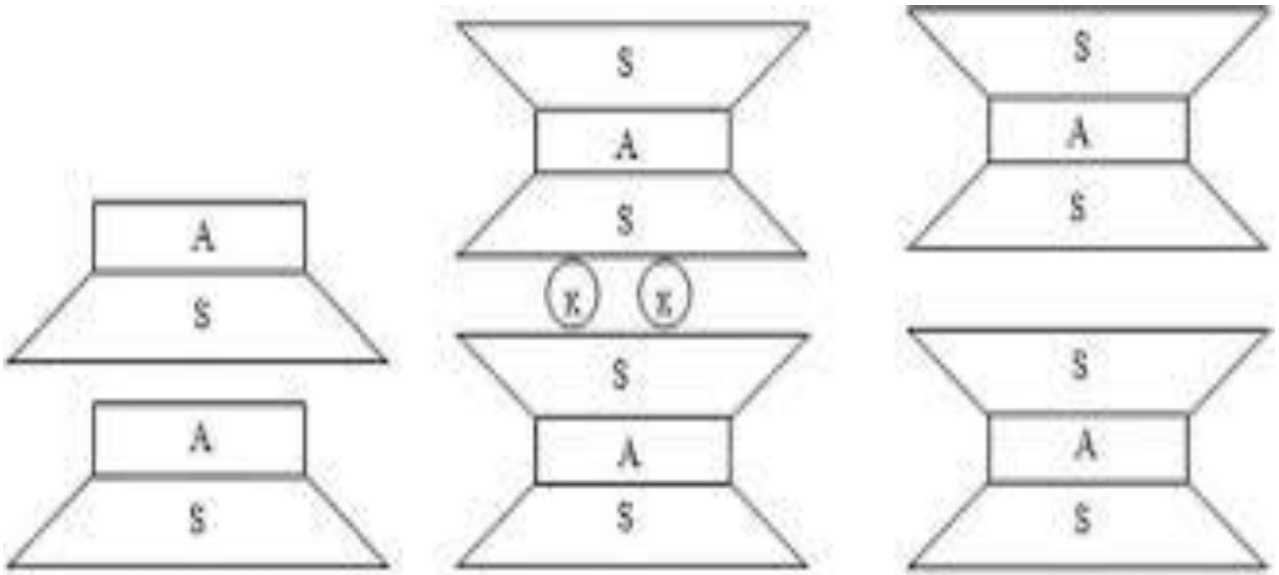


## 3- Illite

Illite also has a three-sheet structure, comprising a sheet of gibbsite sandwiched between two silica sheets. In illite, the layers are separated by potassium ions, whereas in montmorillonite the layers are separated by cations in water. Illites have the same basic structure as the non-clay minerals muscovite mica and pyrophyllite.




Illites usually occur as small, flaky particles mixed with other clay and non-clay minerals. Illite particles range generally from 0.1μm to a few micrometre in length, and may be as small as 3nm thick. Unlike kaolinite and montmorillonite, their occurrence in high purity deposits is unknown.




Kaolinite (a) Illite (b) Smectit (c)

S:Silica layer, A:Alumina layer, K:Potassium ioans

# Groundwater and Aquifers

## Type of water source:

- ❖Surface water
- ❖ Ground water

**Surface water** is water located on top of the Earth's surface such as rivers, creeks, and wetlands. This may also be referred to as blue water. The vast majority is produced by precipitation and water runoff from nearby areas. As the climate warms in the spring, snowmelt runs off towards nearby streams and rivers contributing towards a large portion of our drinking water. Levels of surface water lessen as a result of evaporation as well as water moving into the ground becoming ground water.

## There are three major types of surface water:

- Permanent (دائمي) surface waters are present year round. This includes rivers(الانهار), swamps(المستنقعات), and lakes(البحيرات).
- Semi-permanent (شبه دائمي) surface water refers to bodies of water that are only present at certain times of the year including areas such as creeks (الجداول) , lagoons (بحيرات), and waterholes (ابار المياه).
- Man made surface water (مياه سطحية من صنع الانسان) is water that can be continued by infrastructure that humans have assembled. This would be lakes, dams, and artificial swamps. The surface water held by dams can be used for renewable energy in the form of hydropower.

moves through the soil into the groundwater system, where it eventually makes its way back to surface streams, lakes, or oceans.

## Properties of ground water:

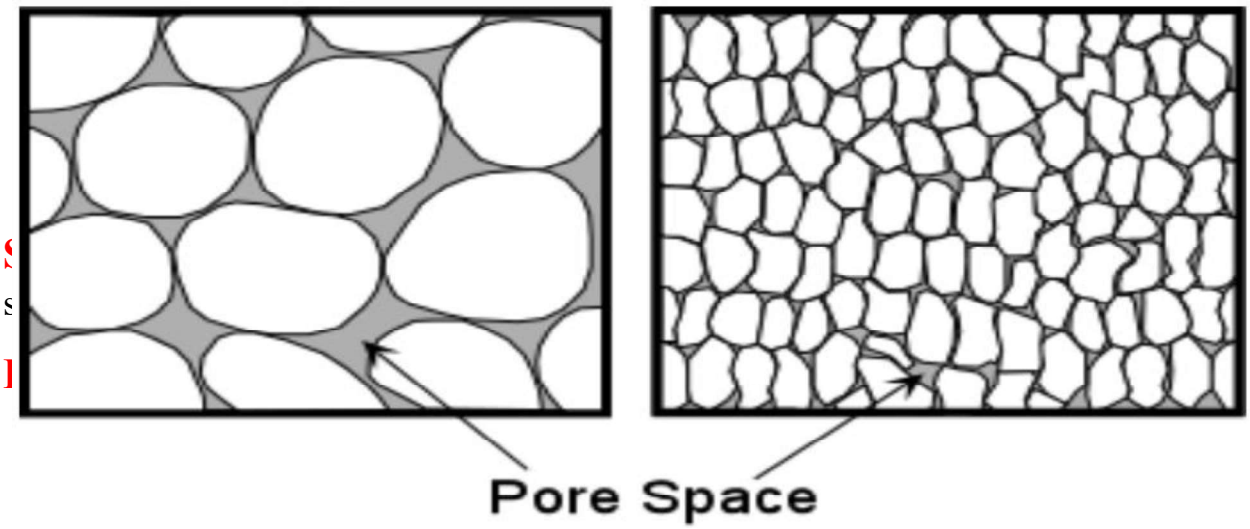
1- Groundwater makes up about 1% of the water on Earth (most water is in oceans).
2- groundwater makes up about 35 times the amount of water in lakes and streams.
3- It is an important resource for potable water, irrigation, and industry.
4- Because it is largely hidden from view, it is often forgotten and subject to contamination by careless humans.

## The Groundwater System:

Groundwater resides in the void spaces of rock, sediment, or soil, completely filling the voids. The total volume of open space in which the groundwater can reside is porosity. Porosity determines the amount of water that a rock or sediment can contain.

## Porosity:

is the percentage of open space within an unconsolidated sediment or a rock. Primary porosity is represented by the spaces between grains in a sediment or sedimentary rock. Secondary porosity is porosity that has developed after the rock has formed. Porosity is expressed as a percentage calculated from the volume of open space in a rock compared with the total volume of rock. Porosity is a measure of how much water can be stored in geological materials. Almost all rocks contain some porosity and therefore contain groundwater. Groundwater is found under your feet and everywhere on the planet.



interconnected, and the size of the interconnections. Low porosity usually results in low permeability, but high porosity does not necessarily imply high permeability. It is possible to have a highly porous rock with little or no interconnections between pores. A good example of a rock with high porosity and low permeability is a vesicular volcanic rock.

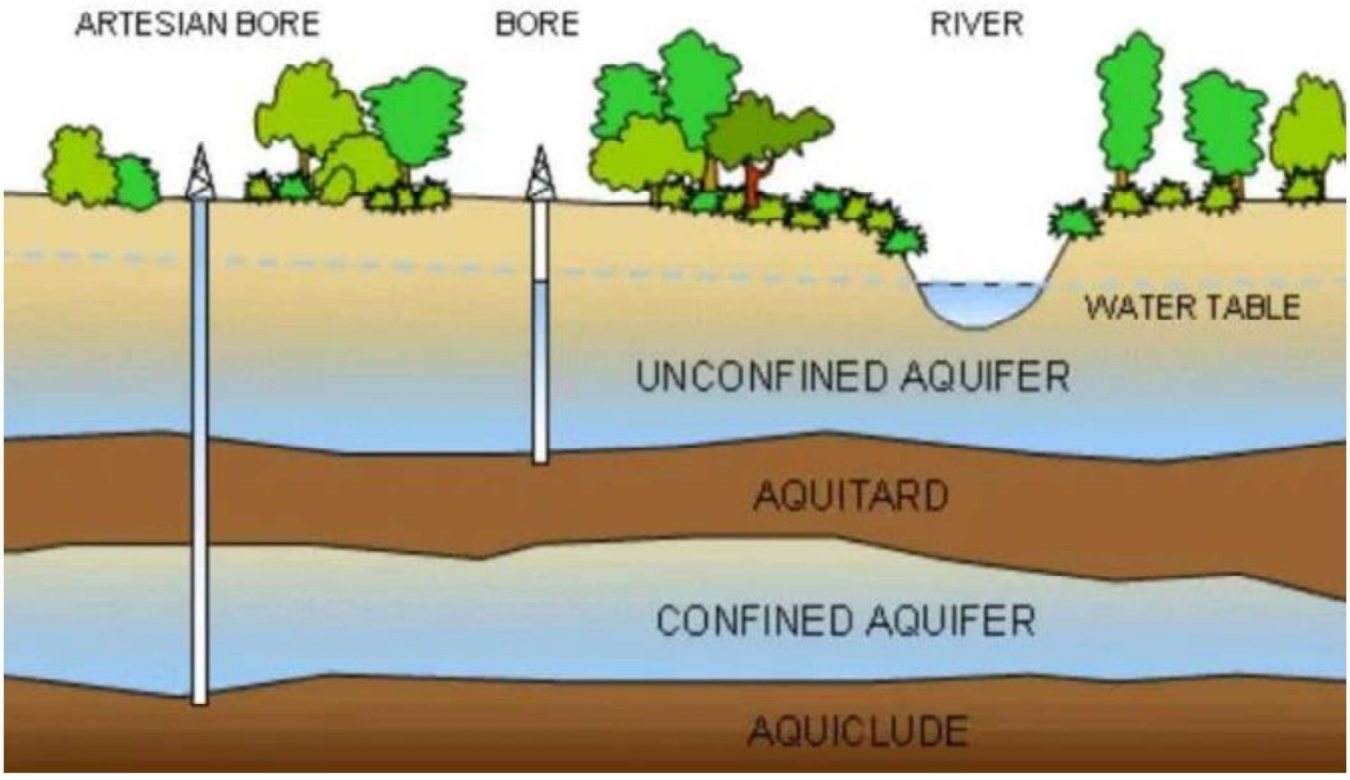
coarse-grained rocks are usually more permeable than fine-grained rocks, and sands are more permeable than clays.

## Aquifers:

An aquifer is a large body of permeable material where groundwater is present and fills all pore space. Good aquifers are those with high permeability such as poorly cemented sands, gravels, or highly fractured rock.

Aquifers can be of two types:

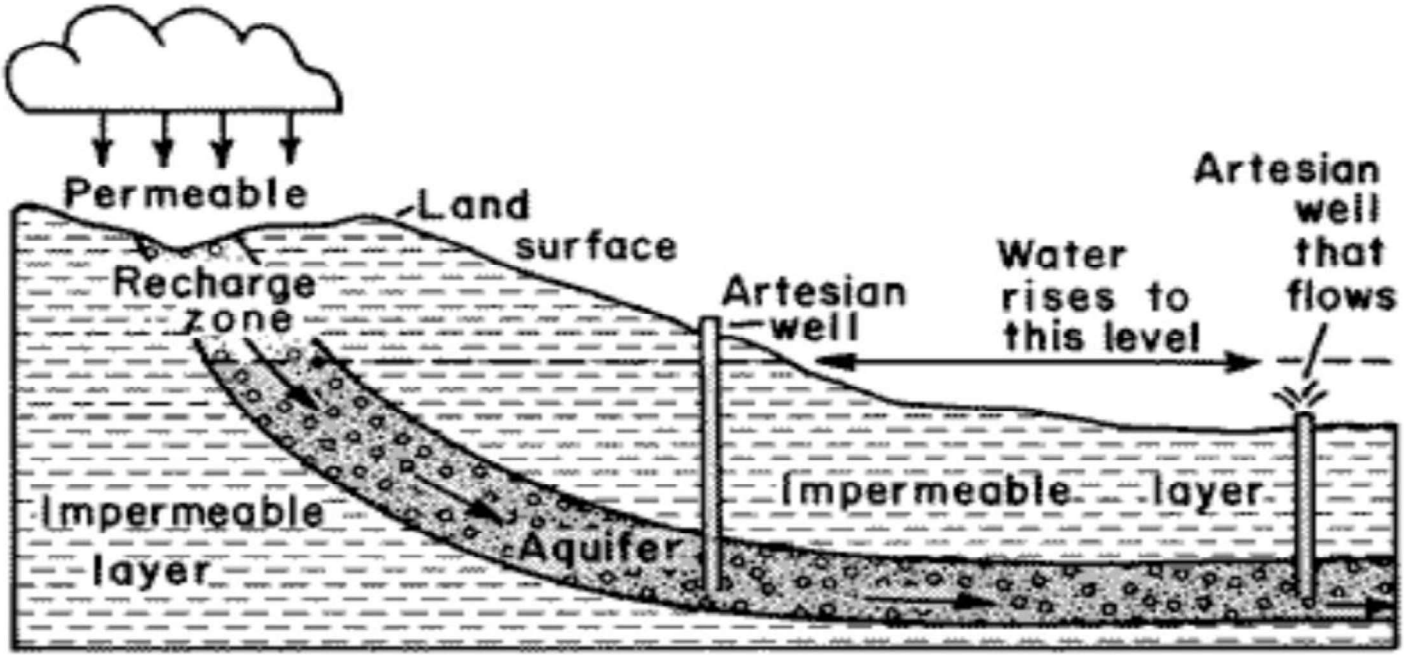
1- **Unconfined Aquifers** - the most common type of aquifer, where the water table is exposed to the Earth's atmosphere through the zone of aeration.
2- **Confined Aquifers** - these are less common, but occur when an aquifer is confined between layers of impermeable strata.



Ground water can be obtained by drilling or digging **wells** (الابار). A well is usually a pipe in the ground that fills with ground water. This water can then be brought to the land surface by a pump. Shallow wells may go dry if the water table falls below the bottom of the well.

Water leaving an aquifer is called **discharge water** (المياه المصرفة ). Water that is pumped from a well is discharge water. Ground water might also discharge naturally as springs (الينابيع) or into swamps (المستنقعات), lakes (بحيرات), or rivers (الانهار).

Some wells, called **artesian wells** (الابار الارتوازية), do not need a pump. These wells are drilled into an **artesian aquifer** (طبقة المياه الجوفية الارتوازية), which is sandwiched between two impermeable layers. Water enters an artesian aquifer in a permeable recharge zone, which can be miles away from the well. When a well is drilled into an artesian aquifer, pressure pushes water in the well above the top of the aquifer. If the pressure is high enough, water can flow from an artesian well.

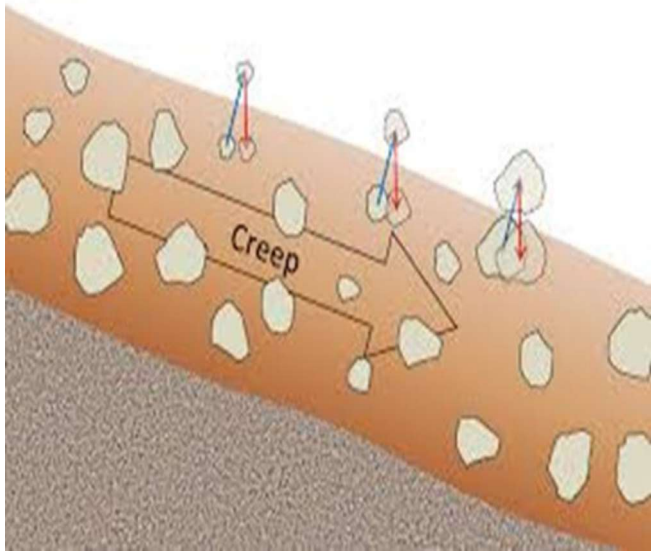


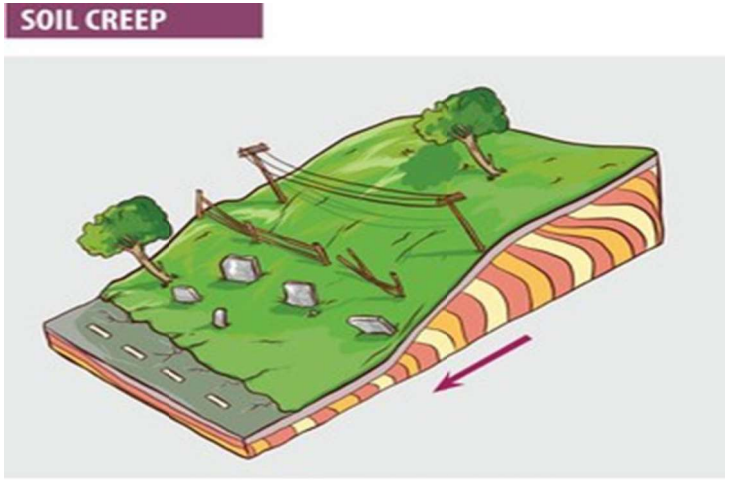
# Soil Creep
# زحف التربة

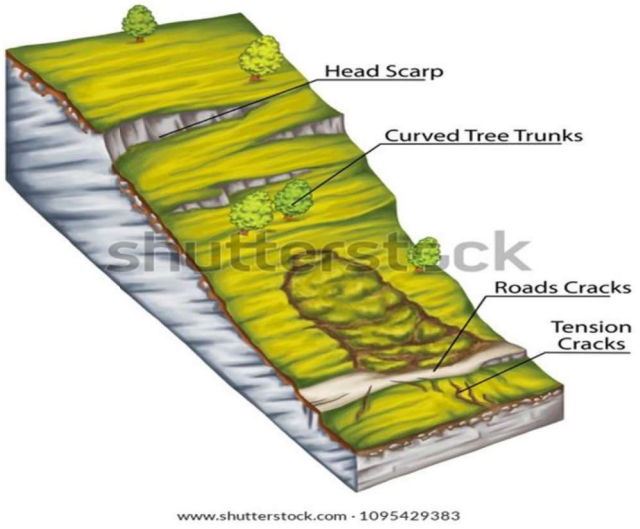
# Soil Creep

This is the slow movement of soil materials down slopes under the influence of gravity. Four kinds of creep: *soil creep, talus creep* , *rock-glacier creep* , and *rock creep*. The first concerns only fine-grained particles; the others involve rock debris.

it can also refer to slow deformation of such materials as a result of prolonged pressure and stress.



## Causes of soil creep

1- Water

2- the expansion of materials

3- Vegetation

## 1- Water

Water is a very important factor when discussing soil deformation and movement. The water offers cohesion to the sand which binds the sand particles together. However, pouring water over the sand destroys it. This is because the presence of too much water fills the pores between the grains with water creating a slip plane between the particles and offering no cohesion causing them to slip and slide away. This holds for hillsides and creeps as well. The presence of water may help the hillside stay put and give it cohesion, but in a very wet environment or during or after a large amount of precipitation the pores between the grains can become saturated with water and cause the ground to slide along the slip plane it creates.

## 2- the expansion of materials such

Creep can also be caused by the expansion of materials such as clay when they are exposed to water. Clay expands when wet, then contracts after drying. The expansion portion pushes downhill, then the contraction results in consolidation at the new offset. Objects resting on top of the soil are carried by it as it descends the slope. This can be seen in churchyards, where older headstones are often situated at an angle and several meters away from where they were originally erected.

## 3- Vegetation

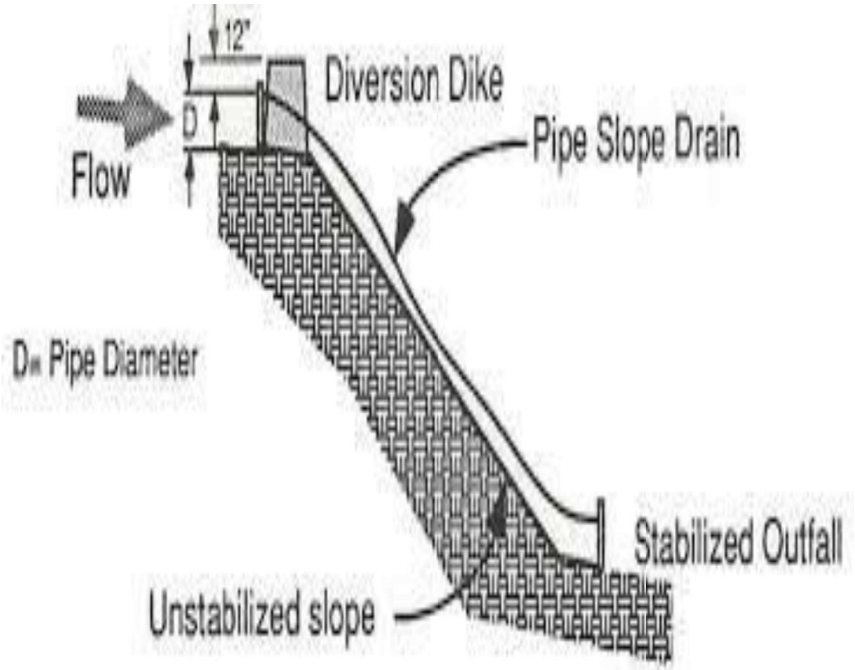
vegetation plays a role in slope stability and creep. When a hillside contains much flora their roots create an interlocking network that can strengthen unconsolidated material. They also aid in absorbing the excess water in the soil to help keep the slope stable. However, they do add to the weight of the slope giving gravity that much more of a driving force to act on in pushing the slope downward. In general, though, slopes without vegetation have a greater chance of movement.

# How to Stop soil Creep

## 1- Divert Water تحويل الماء

Gravity pulls water from the top of the hill to the bottom, and the water grabs soil along the way, causing serious erosion over time. Water movement can be controlled in various ways. Dig drainage ditches or trenches to move the water in a desired direction or place gutters at the top of the hill to direct water into a dry well that holds the runoff until it seeps slowly into the ground. Smaller stone, or riprap, can be placed all along the hillside to slow the water's descent and protect the soil underneath from being carried away. For smaller slopes, partially burying large stones or logs creates baffles that slow and divert running water.

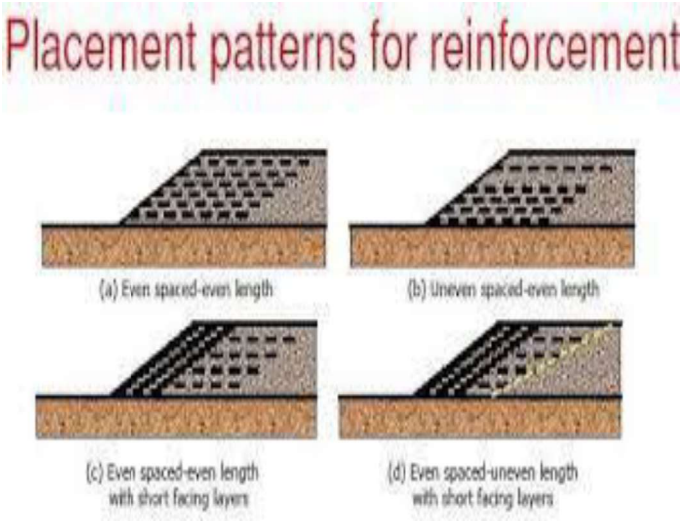


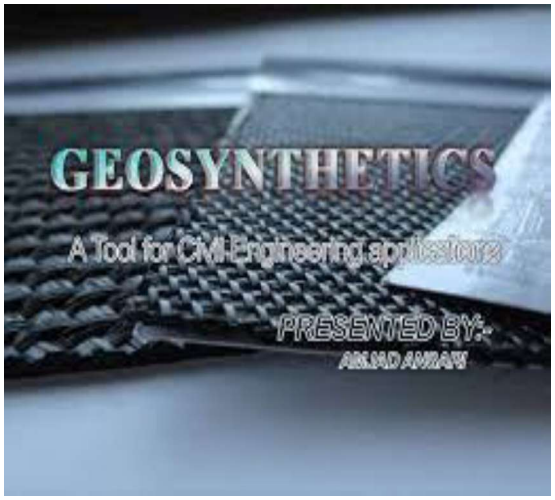

12"
D
Flow
Diversion Dike
Pipe Slope Drain
$D_w$ Pipe Diameter
Stabilized Outfall
Unstabilized slope

## 2- Mats

Erosion control mats or blankets are made of woven biodegradable materials such as straw, coconut or wood. Placed on the slope, they hold the dirt in place for 6 to 12 months before needing replaced

While no biodegradable mats also exist, they can be difficult to remove if your landscaping needs change.

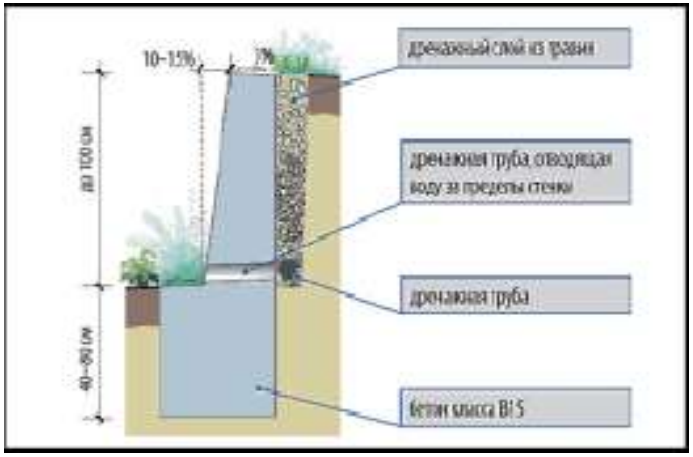


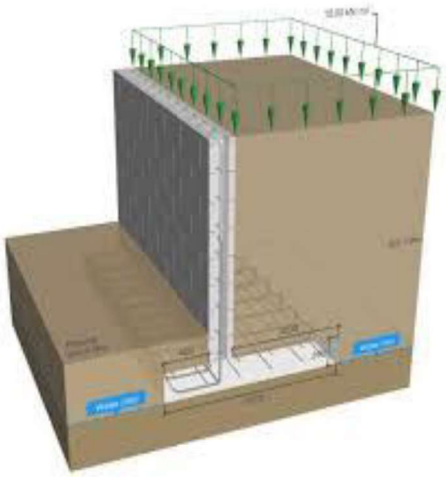



## 3- Retaining walls

Retaining walls are an aesthetically pleasing choice for many homeowners with erosion issues. Available in different materials -- concrete, wood, or stone, for instance -- they can be placed strategically to stop soil erosion at the top of a hill, midway, or at the bottom. And depending on budget constraints, they can be created professionally or by a motivated homeowner.





## 4- Create Steps

Terraces are basically stairs built into a slope with various materials, such as stone, concrete, or wood. The steps divert water and prevent it from carrying soil down the hillside. Water will soak into the soil instead. Landscaping and gardens can be built on and around the terrace steps to create further soil anchors. They can be a less expensive option to stop a serious erosion problem.









## 5- Vegetation

Cover exposed soil with a variety of plants -- trees, shrubs, perennials and annuals -- to create a barrier that stops soil movement from both wind and water. The plants' roots will hold the soil in place, as well. Lay mulch or stone between plants to provide additional coverage of exposed dirt. For the best results, know what type of soil covers your slope, and choose native plants that thrive in that soil type.



# 6- Anchors

