

**Tikrit University**  
**The College of Petroleum Processes**  
**Engineering**  
**Petroleum and Gas Refining Engineering**  
**Department**

An Introduction to Petroleum Technology

First Class

Lecture (2)

By

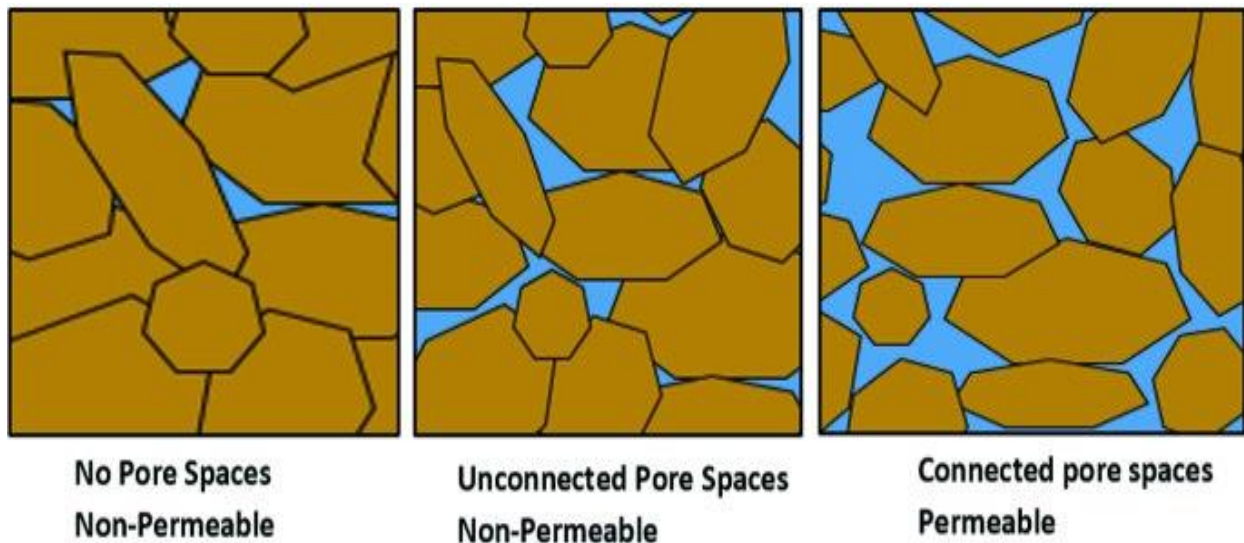
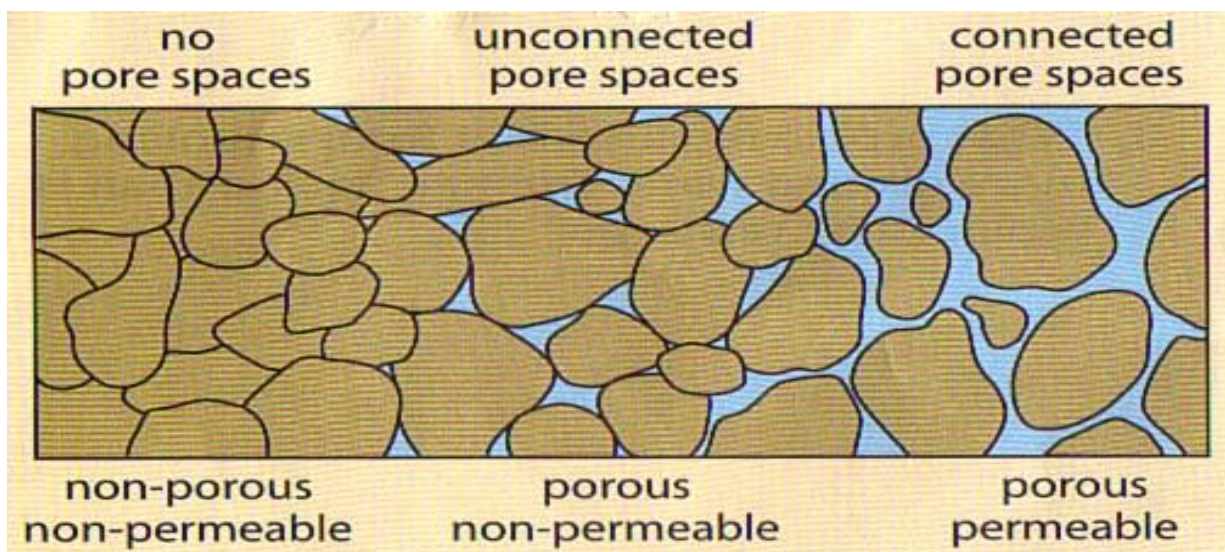
Assistant lecturer

Luay Ahmed Khamees

## 2-1 Reservoir rocks:

They are rocks in which hydrocarbons accumulate after migrating from the source rocks. Reservoir rocks are characterized by being permeable rocks and rocks with effective porosity, allowing fluids to pass through them.

*And rocks, if they are not permeable, then fluids cannot collect in them, and therefore they cannot form an oil reservoir.*



**Reservoir rocks are the third figure on the far right.**

Reservoir rocks consist of: grains that have aggregated and packing to each other by means of cementation.

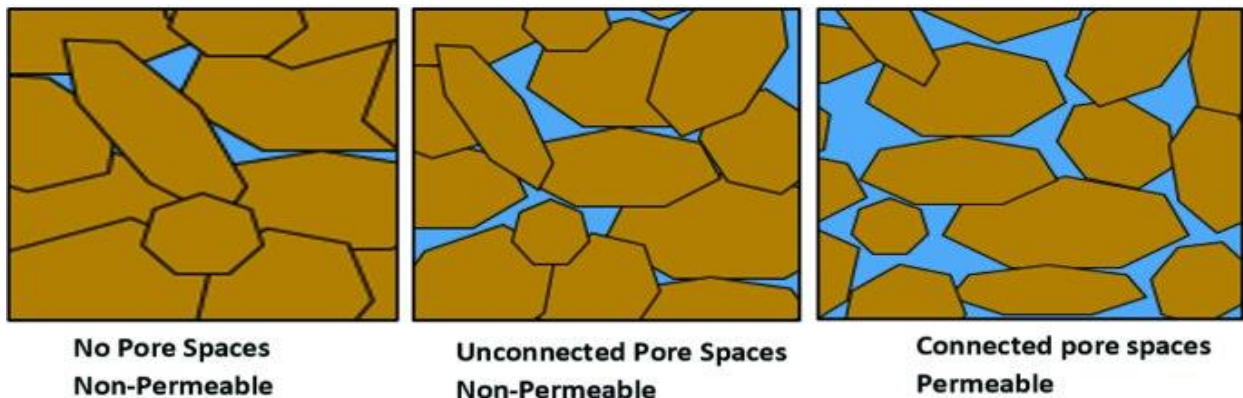
Within these grains, there are interconnected pores that allow fluids to pass through, which is called permeability.

## 2-2 Seal Rock ( Cap rock):

A reservoir must have an impervious seal or cap rock that ensures that hydrocarbons are preserved over geological time. Cap rocks are mostly sedimentary due to their ability to deform under stress, unlike igneous and metamorphic rocks. Though cap rock can have pore spaces, the absence of interconnected pores (permeability) ensures the hydrocarbon does not escape from reservoirs. Common reservoir seals include shales, clay, chalk, and evaporates (salt, Gypsum) .

Sealing rock consists of: grains aggregated and packed together by means of cementing.

There are no pores inside these grains, and there may be pores inside it, but these pores are not interconnected, so they do not allow liquids to pass through them, which makes them impermeable rocks..



The reservoir rocks are the first and second figures from the left.

## 2-3 Traps

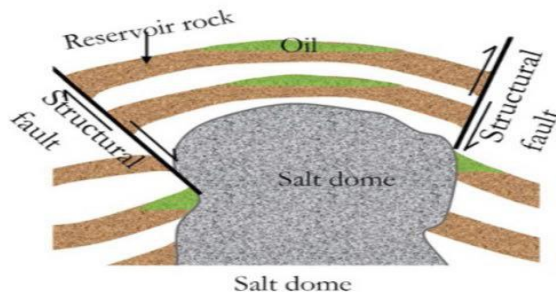
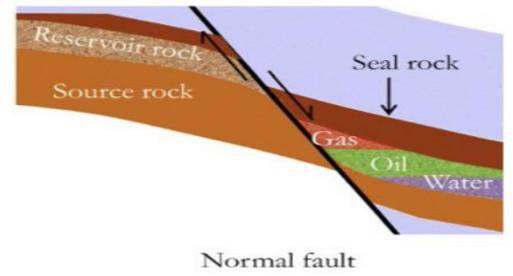
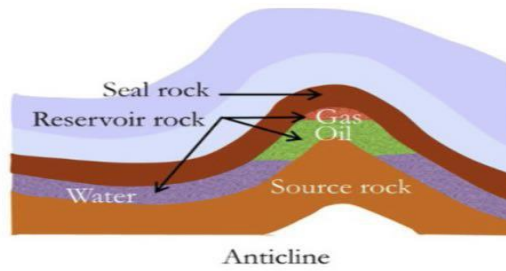
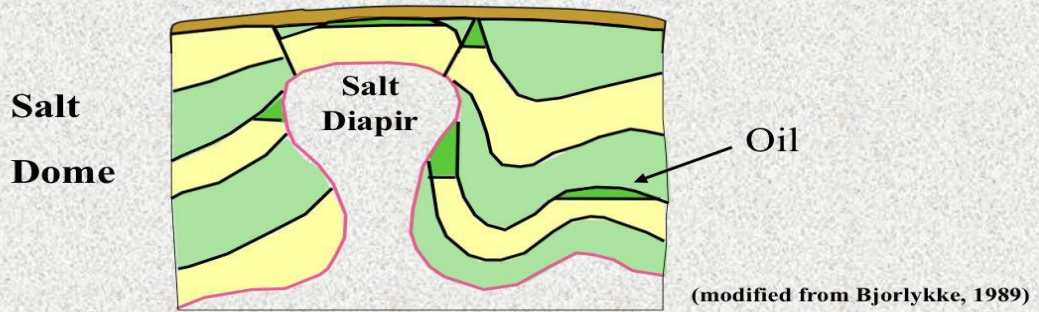
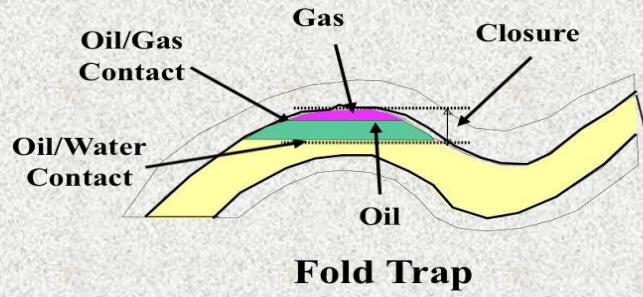
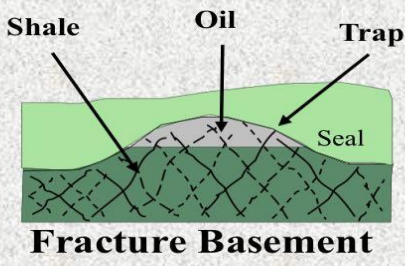
Traps: is an arrangement of rock layers that contain an accumulation which is covered by cap rock to prevent hydrocarbon from rising to the surface . it consists of an impermeable layer of rock above , porous, permeable layer containing the hydrocarbon . There are three types of reservoir traps:

- **Structural traps**
- **Stratigraphic traps**
- **Combination traps**

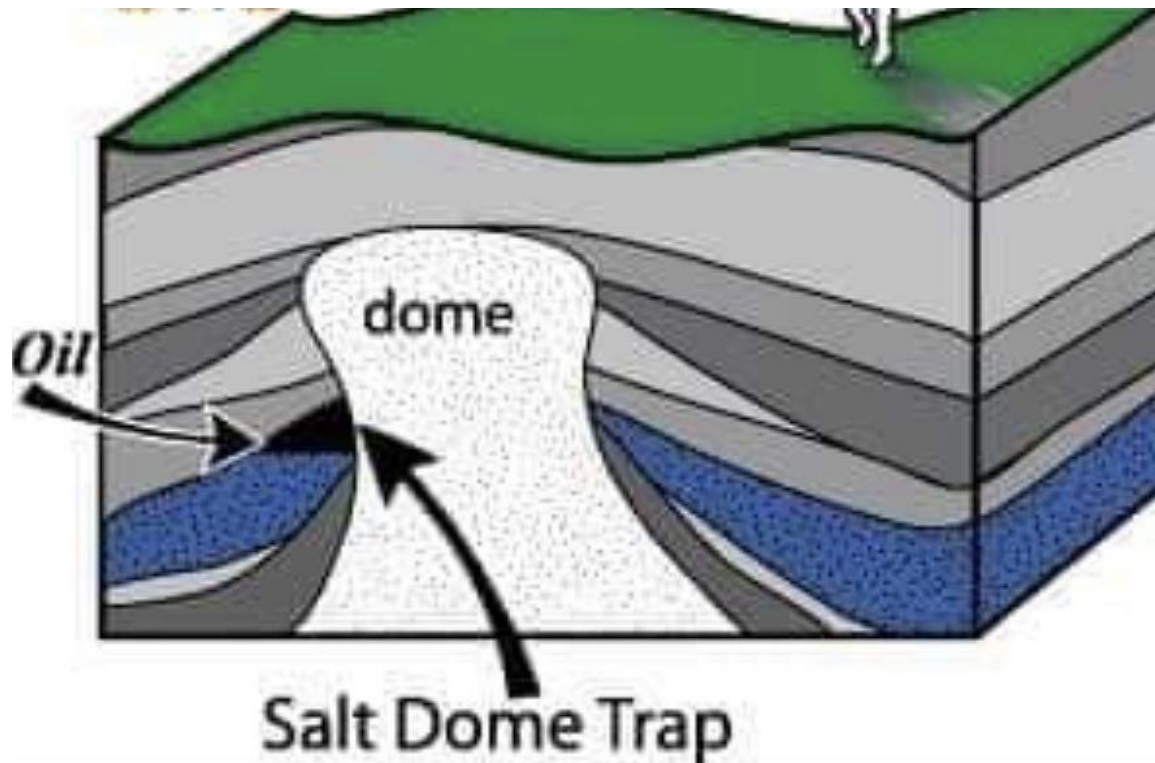
1- Structural traps: traps formed by ground movements that occur in the earth's crust such fold traps (anticlines), fault traps, and salt dome traps. The majority of the world hydrocarbon reservoir (about 78%) is characterized by structural traps (Fig. 1.2).



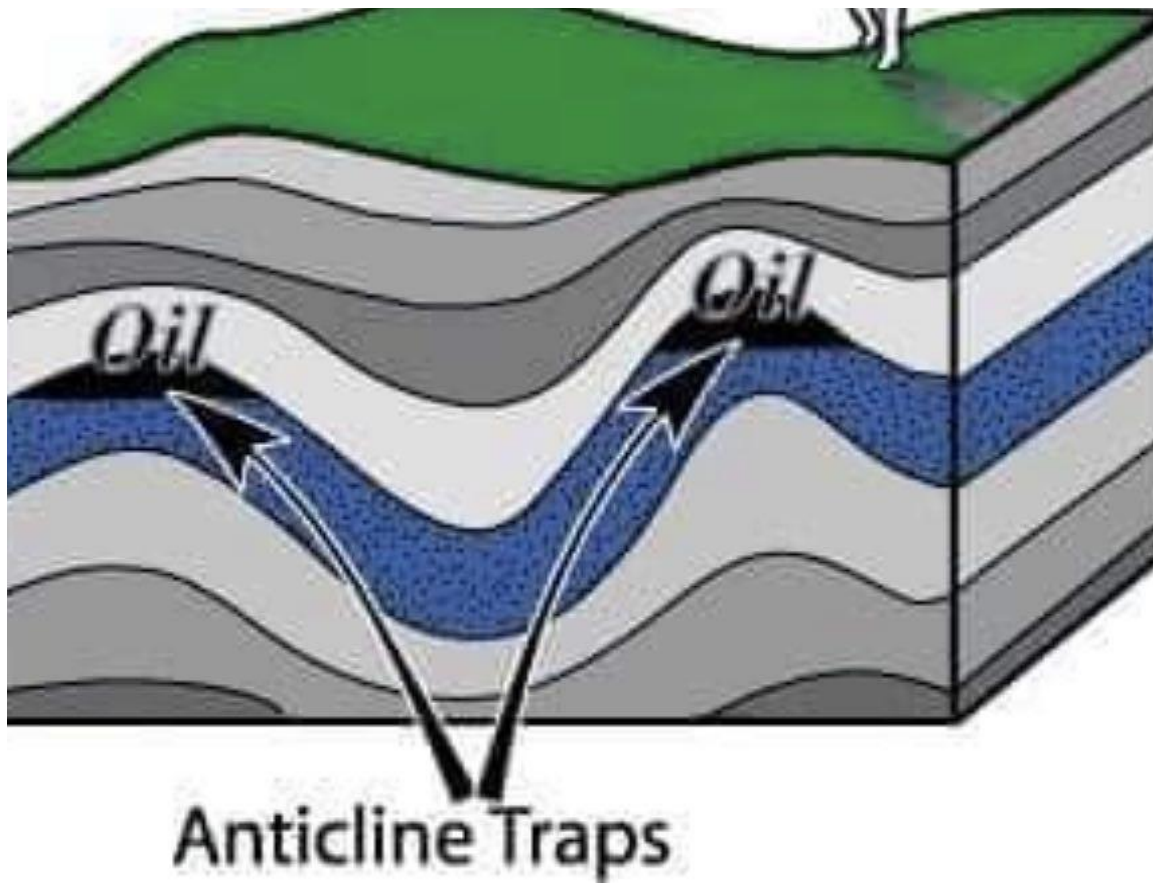
# Structural Hydrocarbon Traps



**Figure 1.2** Structural traps.



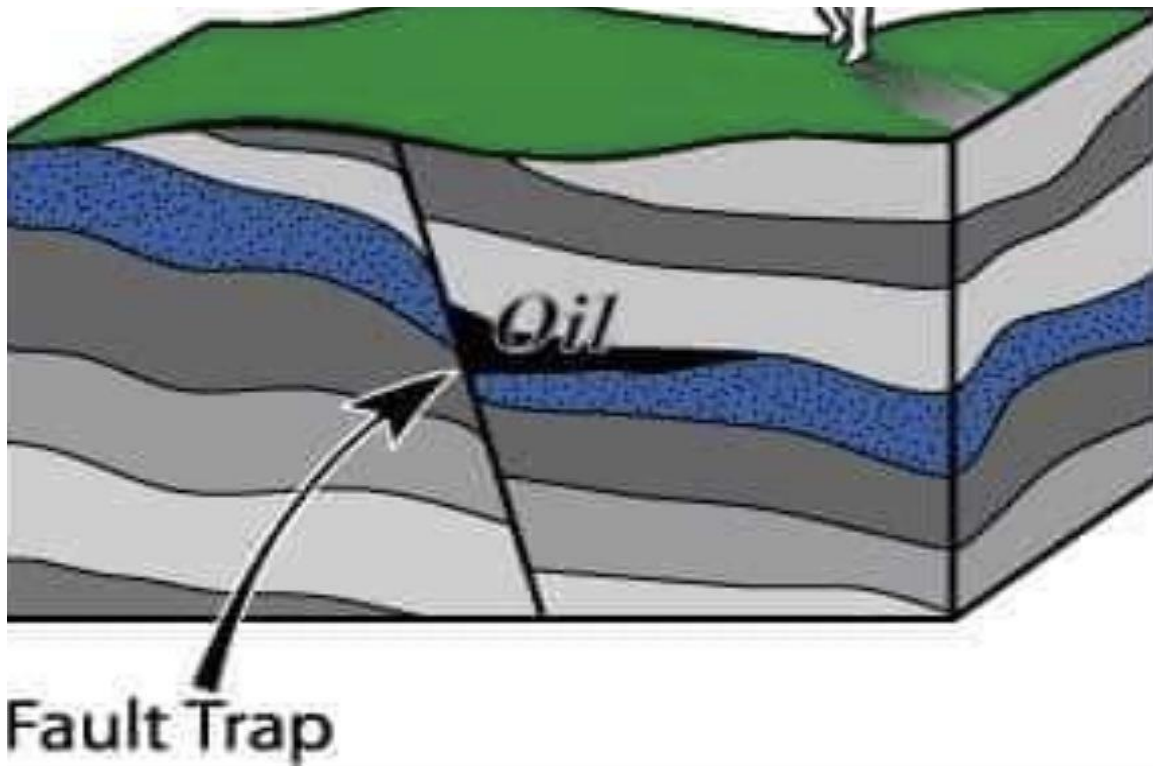
Salt dome traps are formed as a result of the movement of blocks of salt upwards. It is formed as a result of the different densities of the salt and the sedimentary layer above it. The salt is less dense so it moves up, causing the formation of domes.



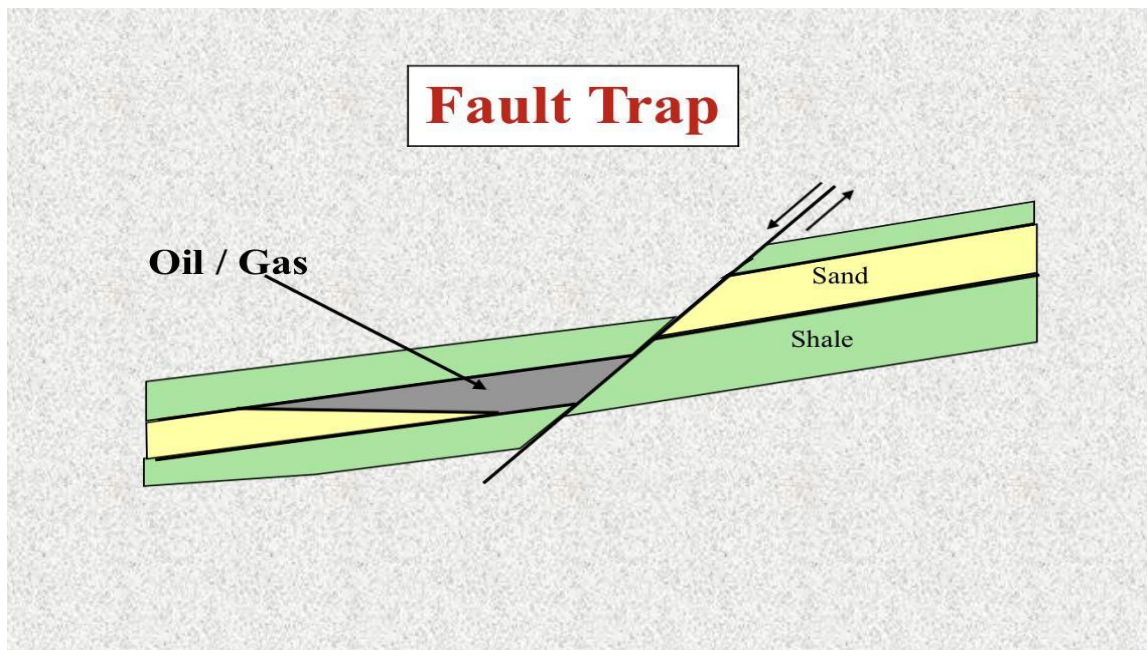
Anticline Traps:

Where the petroleum collects is at the top of The convex fold.





Fault Trap: Faults place impermeable strata in the path of petroleum-bearing strata.

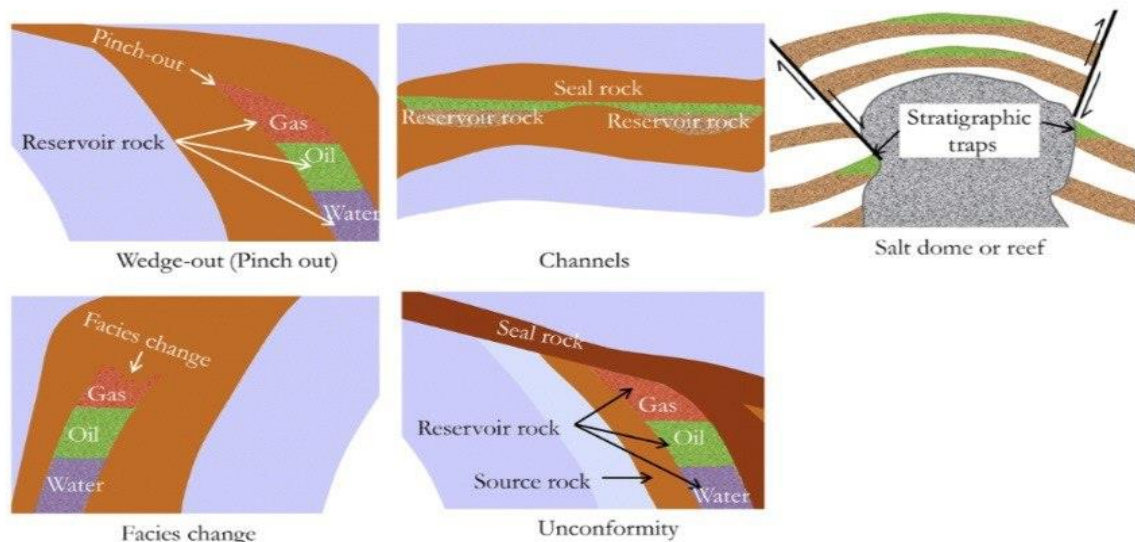




2- **Stratigraphic traps**, formed during the sedimentation process. They are primary stratigraphic traps which resulted from discontinuous deposition of sediment (changes in lithology) and secondary stratigraphic traps which arise from changes in porosity of the rock after sedimentation has occurred.

About 13% of the world reservoir is characterized by this

Kind of trap (Fig. 1.3).



**Figure 1.3** Stratigraphic traps.

3- **Combination Traps**: There is also the possible combination of structural and Stratigraphic traps. About 9% of the world reservoir is characterized by this kind of traps.

## **2-4 petroleum system**

petroleum system : petroleum system consist of six elements :

1- Source rock.

2- Generation .

3- Migration .

4- Reservoir rock.

5- Seal rock.

6- Trap .

## **2-5 Reservoir:**

In petroleum engineering , a reservoir is the place where the hydrocarbon reside . our job as petroleum engineering is to access reservoirs and extract the hydrocarbons in an economical and environmentally safe manner .

### **2-5-1 Distribution of hydrocarbons:**

In general , there are two forces affecting the distribution of hydrocarbon in the porous , which are:

1- Gravity force (gravitational ) this force cause the less dense (light) fluids to seek the higher positions in the trap. The gravity force makes water run downhill.

2- Capillary force : tend to make a wetting fluid to rise into pore space containing a non wetting fluid.

Capillary tends to counteract the force of gravity in segregating the fluid.

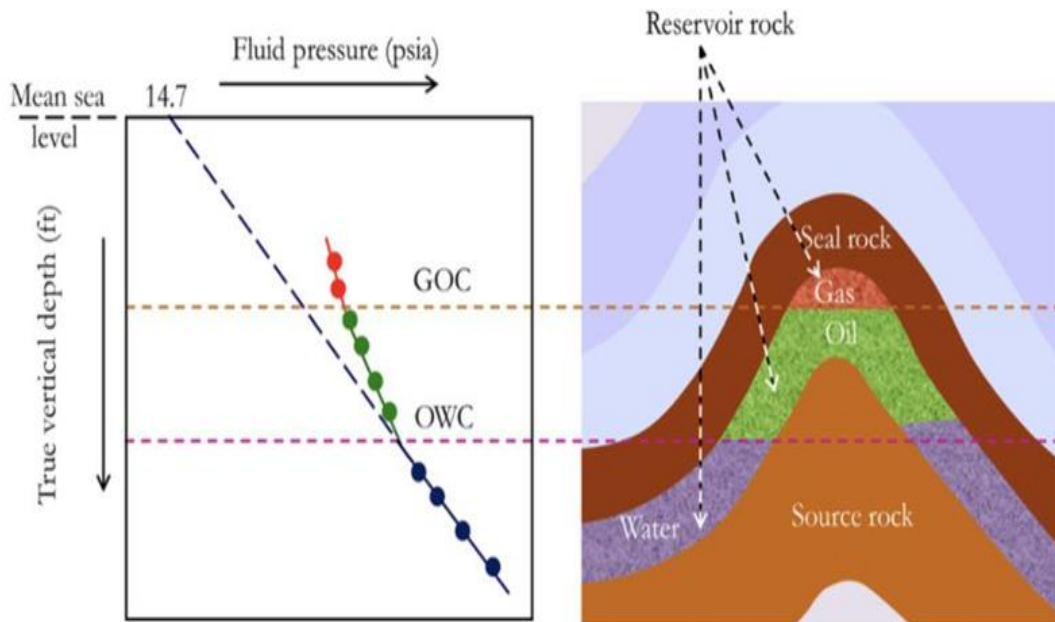
**Note :**

- In general water is wetting fluid with respect to oil and gas.
- Before oil production , an equilibrium exists between the capillary and gravitational forces .

**Oil water contact:** The contact surface between water and oil.  
The deepest level of oil production.

**Gas oil contact :** The contact surface between gas and oil.  
Lowest level of oil production.

It is necessary to determine these two surfaces accurately before calculating the oil and natural gas reserves in the reservoir and estimating the production rate.



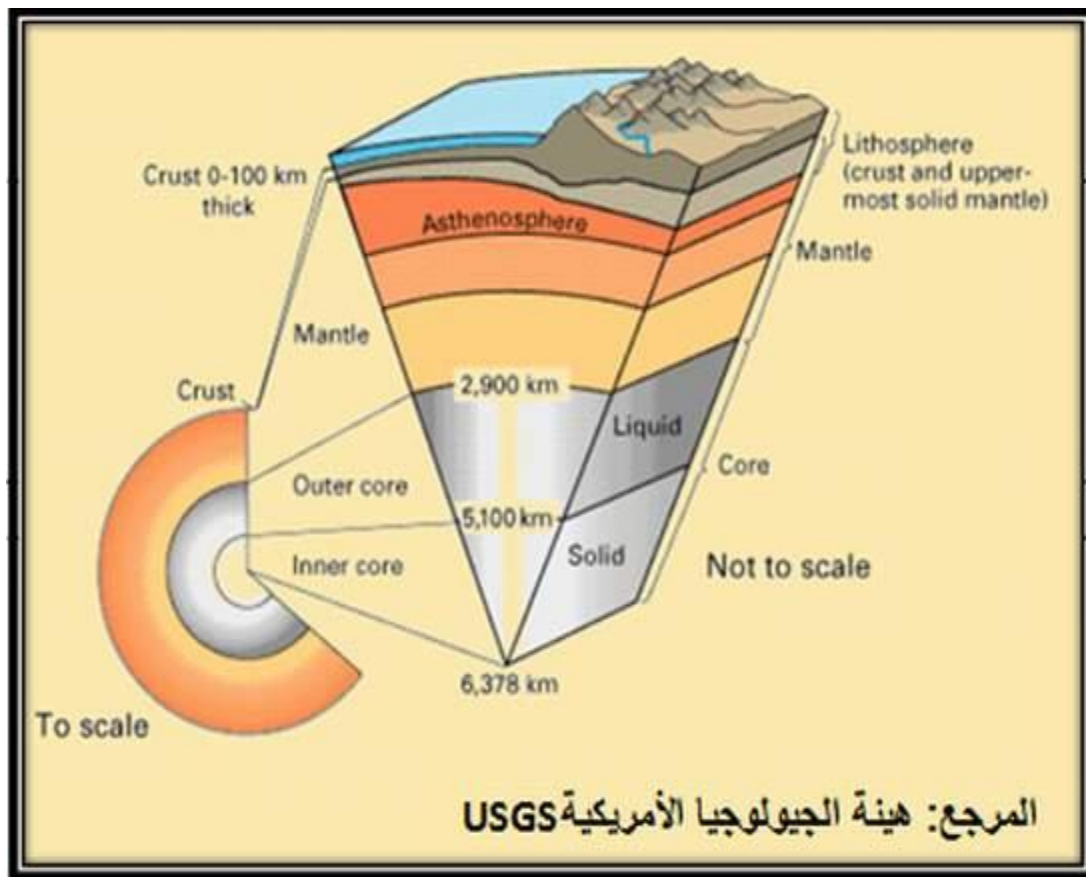
**Figure 1.4** Reservoir fluid zones in a normally pressurized petroleum reservoir.

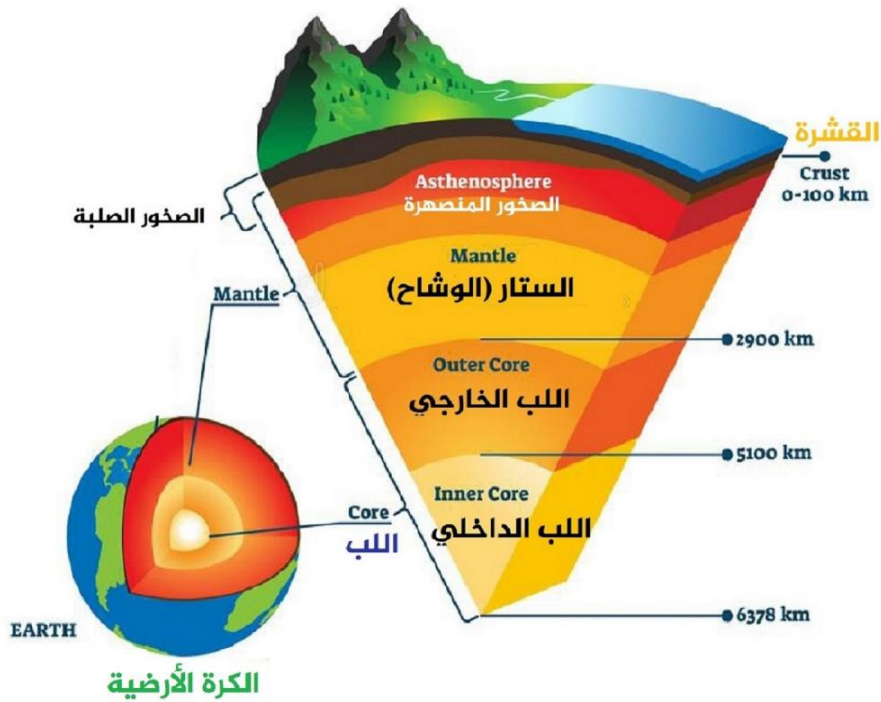


## 2-6 Earth's geological layers

The earth consists of four main layers:

- 1- Crust (0-100 km).
- 2- Mantle (100- 2900 km).
- 3- Outer core (2900- 5100 km).
- 4- Inner core (5100- 6378 km).





## The rocks:

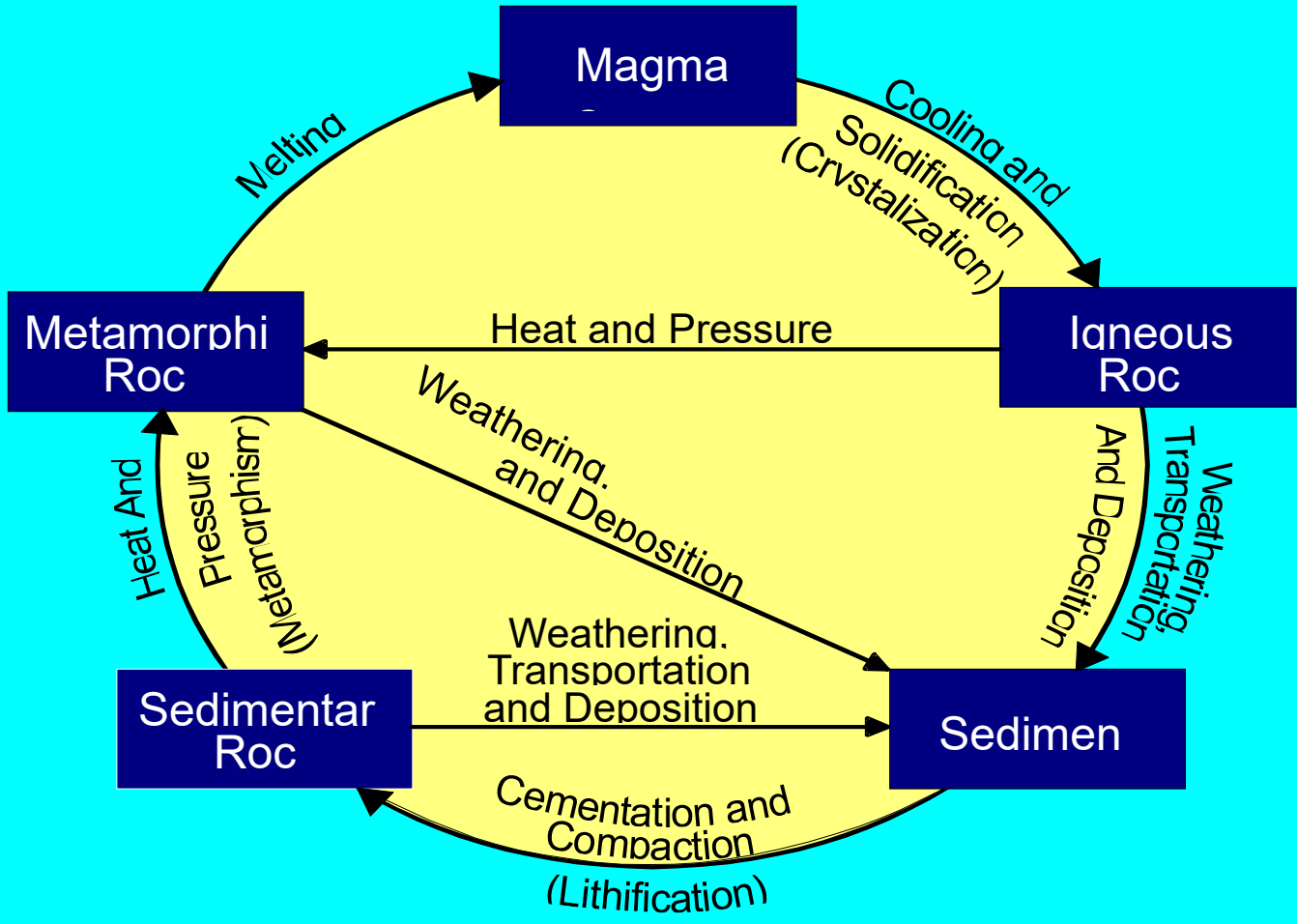
The rocks of the earth's crust are constantly being recycled. Magma solidifies to form igneous rocks. If igneous rock are exposed at the surface, they weather, and weathered rock fragments are transported and sediment, deposited, and lithified into sedimentary rocks. If the igneous or sedimentary rocks are subjected to temperatures and pressures that exceed those under which they solidified, they may undergo changes to form metamorphic rocks.

## **2-6-1 Rocks are divided into three main types:**

- 1- Igneous rocks.
- 2- Sedimentary rocks: They are originally Igneous rocks, but under the weathering, and erosion they turned into sedimentary rocks.
- 3- Metamorphic rocks: Mutant rocks, originally sedimentary rocks, have been transformed under the influence of pressure and heat factors over time.

There is a relationship between these types of rocks, as rocks are transformed from one species to another as a result of the continuous physical and chemical processes in nature such as weathering, erosion, pressure, heat and melting. Rock transformations from one species to another continue in nature and are called the **geological cycle of rocks**.

# The Rock Cycle







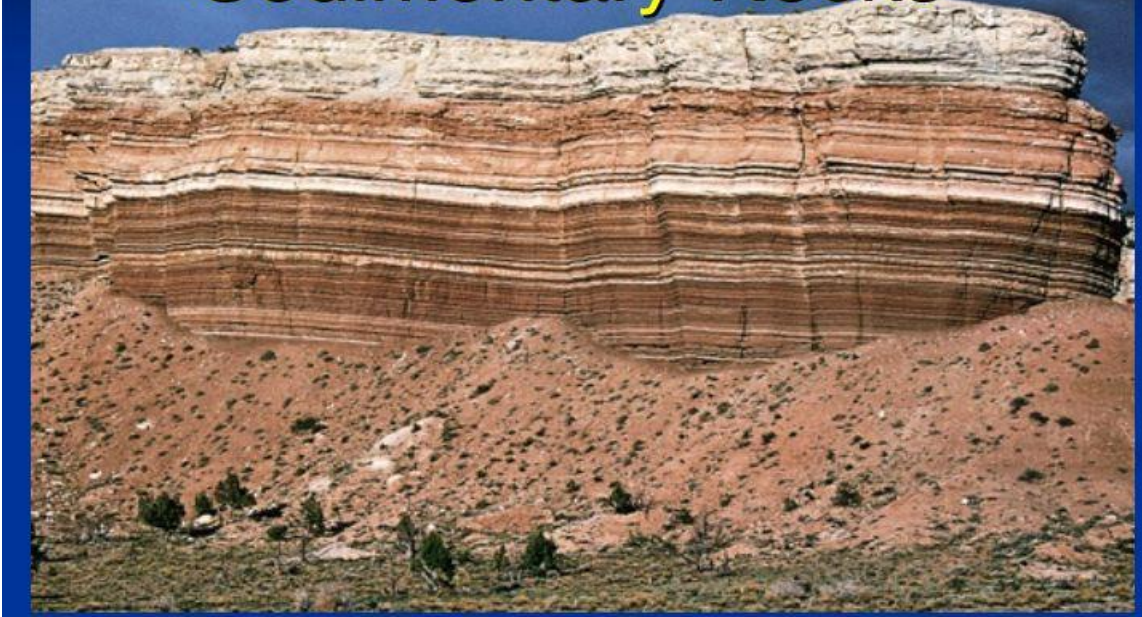
Igneous rocks



Metamorphic rocks



# Sediments and Sedimentary Rocks



## TYPES OF ROCKS



Igneous Rock



Sedimentary Rock



Metamorphic Rock

பாறைகள்

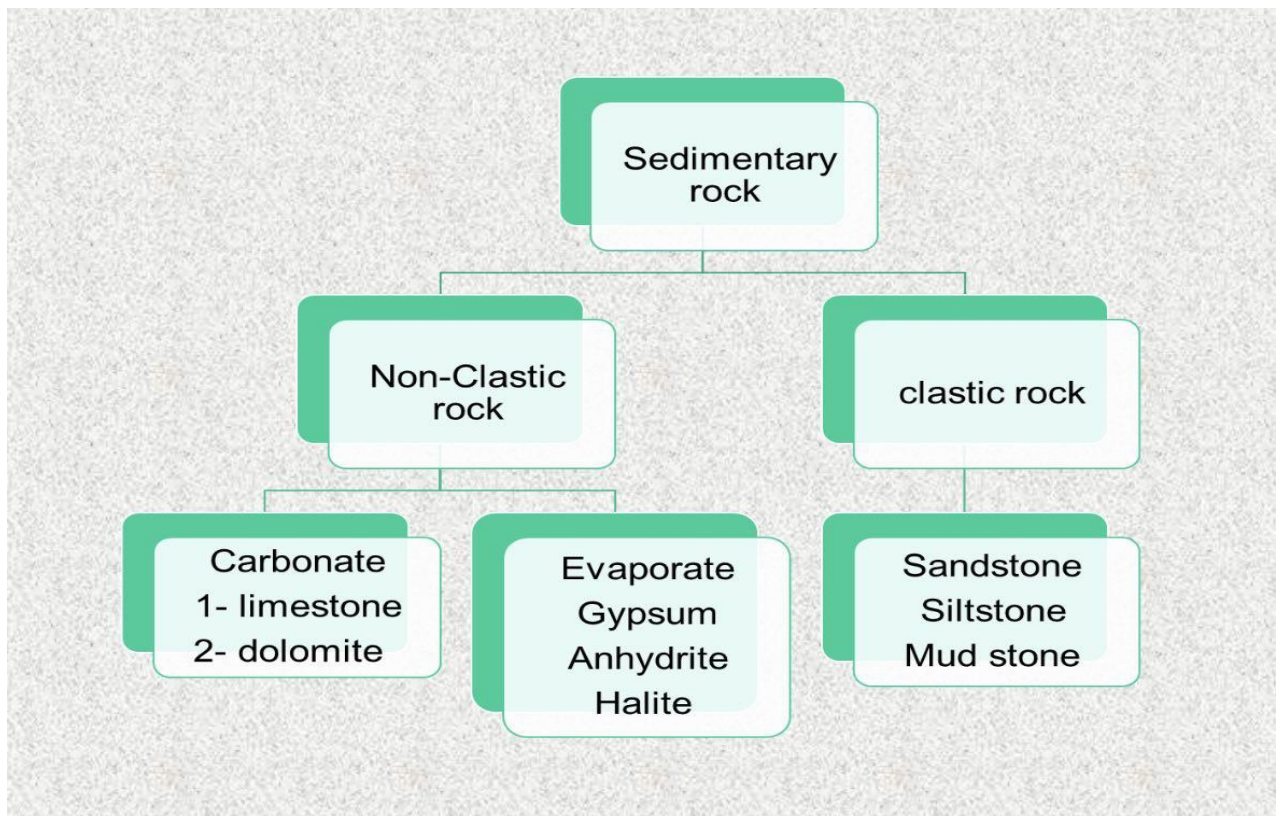
**Note: The hydrocarbons are found only in sedimentary rocks.**

**The most important properties of sedimentary rocks:**

- 1- Stratification, they exist in nature in the form of successive layers according to the time of their formation, and these layers differ in color, thickness and composition.
- 2- Sedimentary rocks usually contain the remains of organisms called fossils.
- 3- Sedimentary rocks are characterized by the pores between the grains that make them up, so they are considered natural reservoirs for groundwater and natural gas.
- 4- Sedimentary rocks can resist weathering to a lesser extent than igneous rocks.

# Sedimentary Rock Types

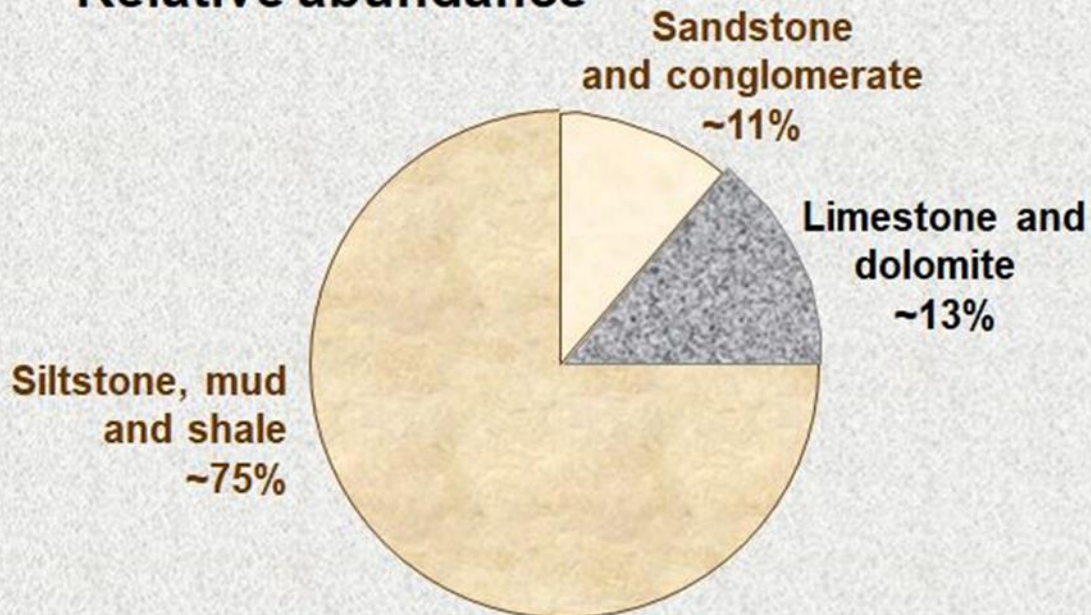
- **Clastic rock**
- **Non-clastic rock**





# Sedimentary Rock Types

- **Relative abundance**



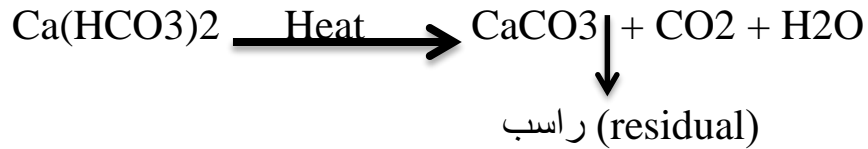
## 2-6-2 Types of sedimentary rocks:

1- Sandstone: It is formed as a result of the cohesion of sand grains, which are mostly quartz.

2- Clay and shale: These rocks consist of clay sediments in estuaries and the seabed, the majority of which are composed of kaolin, quartz and magnesium oxides.

3- Limestone: These rocks consist mainly of calcium carbonate as a result of their deposition, and the deposition is often due to the

decomposition of dissolved calcium bicarbonate by heat, as shown in the following equation:



4- Dolomite: Limestone may be exposed to the run-off of groundwater carrying magnesium, so it replaces some of the calcium, so a new rock is formed, which is dolomite: Its chemical symbol is :  $\text{CaMg}(\text{CO}_3)_2$ .

Limestone is characterized by the presence of voids and cracks, so it is suitable as a reservoir rock.

As for dolomite, it is also suitable to be a reservoir rock, but the voids connected to it are less than the voids connected to the limestone.

<b>Sandstone</b>	<b>Carbonates</b>
<ol style="list-style-type: none"> <li>1. Usually composed of silica grains ( mainly quartz and some feldspar).</li> <li>2. Consolidated ( the rock is combined as one unit) or loosely consolidated .</li> <li>3. May contain swelling clays (clays have negative impact on reservoir quality)</li> </ol>	<ol style="list-style-type: none"> <li>1. Two major types are limestone (<math>\text{CaCO}_3</math>) and dolomite (<math>\text{CaMg}(\text{CO}_3)_2</math>).</li> <li>2. Pore space consists of inter or intragranular porosity as well as areas of dissolution and fractures .</li> </ol>