Introduction

What is Petroleum ?

Petroleum literally mean(rock oil). The world comes from the Latin world (petra) meaning rock and the world (oleum) meaning oil.

The oil we find underground is called crude oil.

Crude oil is made of mixture of different chemicals called hydrocarbons .

These were produced when tiny plants and animals decayed underground layers of sand and mud.

The crude oil is often mixed with gasses and water.

Oil and Gas are natural resources' of enormous economic importance.

Together they provide about 60% of all the energy used by society today.

Origin of petroleum

What exactly are oil and gas?

Oil and gas are complicated mixtures of different hydrocarbons.

The hydrocarbons is a large organic molecule.

Short chain hydrocarbons like methane are gases .

Medium chain hydrocarbons like paraffin are liquids.

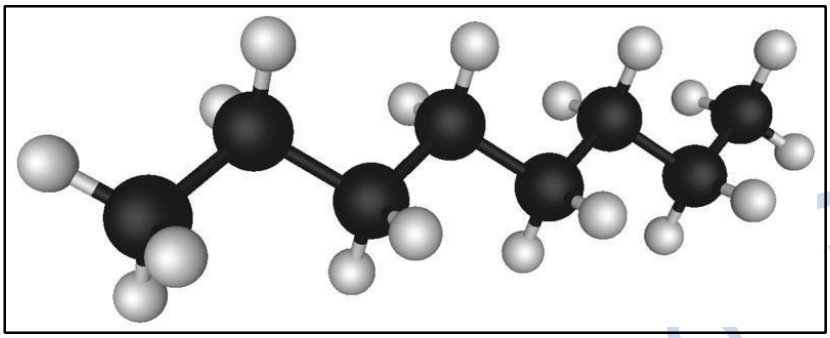
Long chain hydrocarbons like bitumen are solids.

When crude oil is extracted from the earth it may be a mixture of hydrocarbons in solids ,liquid and gas states .

Origin (1): Chemistry

Oil and gas are made of a mixture of different hydrocarbon, As the name suggests these are large molecules made up of hydrogen atoms attached to a backbone of carbon.

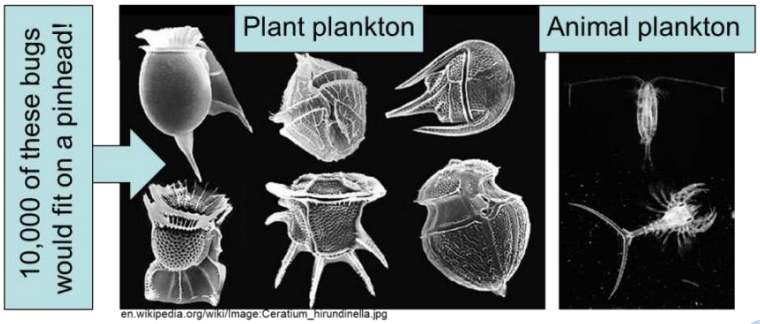
Hydrocarbon



Origin (2): Plankton

It may come as a surprise but most of the world's oil and gas is made up of the fossil remains of microscopic marine plants and animals. That's why oil and gas are often referred to as a fossil fuel. One of the most important group of plankton involved in the formation of oil and gas are single-celled marine 'plants' called dinoflagellates, though many types of animal plankton are also important. Some oil and gas may have also originated from the remains of land plants, but we will not discuss these types of deposits in this talk.

Origin (2): Plankton



- Most oil and gas starts life as microscopic plants and animals that live in the ocean.

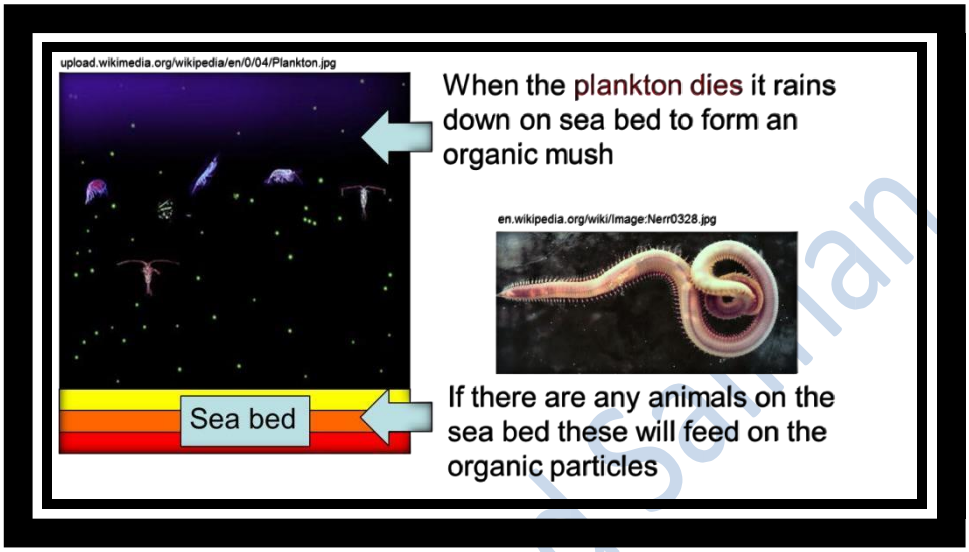
Origin (3): Blooms

In certain parts of the world's oceans, plankton occurs in enormous quantities, or **blooms**. Exactly where those plankton blooms occur is controlled by ocean currents. The richest sites are where cold, nutrient rich waters rise to the surface from the deepest parts of the ocean. The nutrients found in these 'upwelling zones' feed plankton and allow them to reproduce quickly. A single liter of seawater may contain several million dinoflagellates. Where these plankton occurs in high numbers they may turn the water red. This phenomenon is known as red tide.

Dinoflagellate bloom

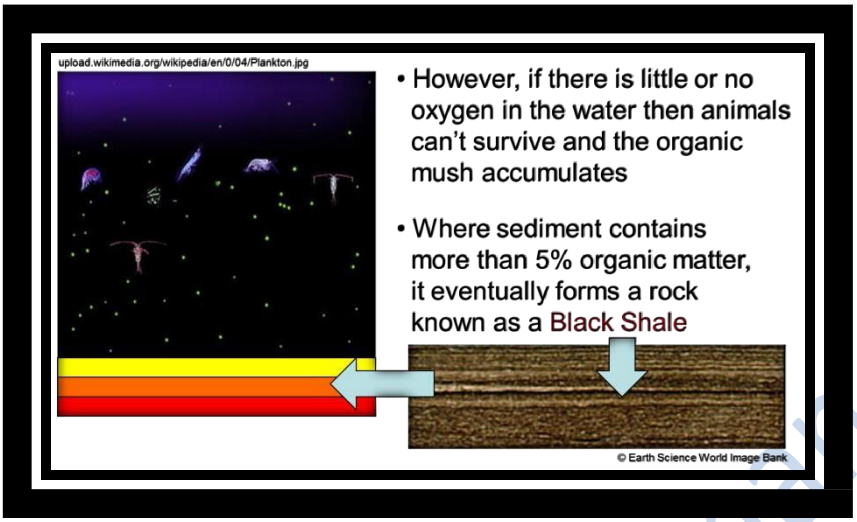
Origin (4): On the sea bed

When plankton dies it slowly settles to the sea bed where it forms an organic mush. Usually there are lots of animals living on the sea floor that feed on this material. One important group is the polychaete worms. These are detritivores, which means they eat the dead and decay remains of other organisms.

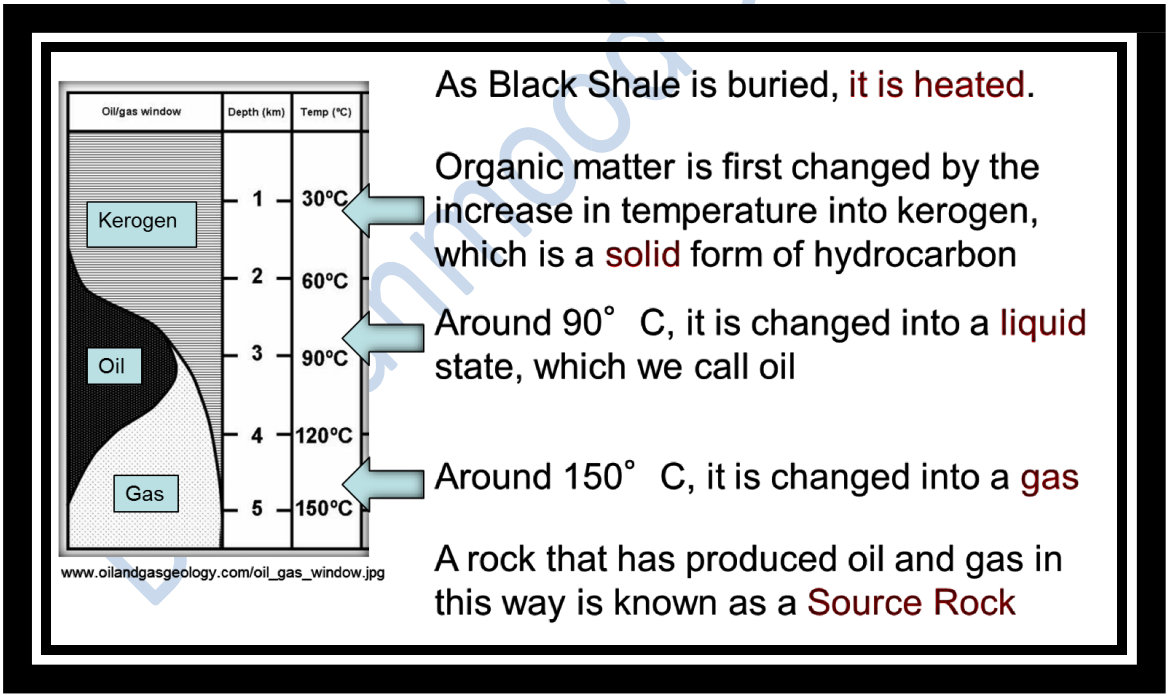


Origin (5): Black Shale

However, under certain conditions there may be very little oxygen on the sea floor. This may be because the ocean is deep and stagnant and oxygen has not been mixed down from the surface waters. No animal life can survive where the sea bed is completely lacking oxygen. Without animals to eat the dead plankton, the organic mush builds up on the sea bed. Where ocean sediment contains more than 5% organic mush it eventually forms a rock known as a Black Shale. The black colour comes from the dark organic matter that it contains. As we will see, Black Shale is what makes oil and gas.



Origin (6): Cooking



As more sediment accumulates on top, layers of Black Shale become buried more and more deeply in the Earth's crust. As they do so, they slowly heat up because of the geothermal gradient. With progressive heating the organic material in the plankton undergoes chemical and physical changes. It gradually breaks down into smaller and smaller hydrocarbons. At temperatures of around 30°C, a solid, sticky

bitumen is produced. Around 90°C liquid oil is formed. As temperatures reach 150°C, natural gases like methane are given off. A Black Shale that is heated and gives off oil and gas is known in the oil industry as a Source Rock.

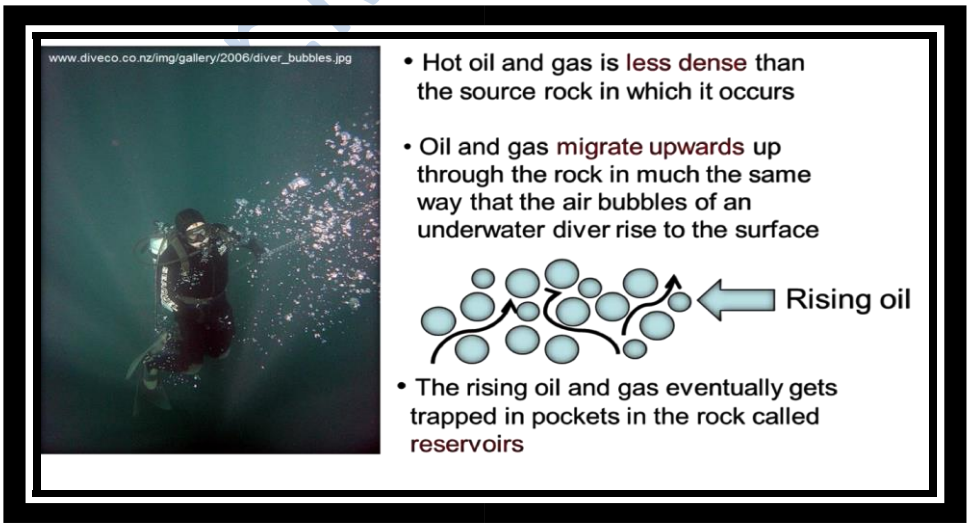
This is natural chemical 'cracking' of the hydrocarbons – where the initially large molecules are broken into progressively smaller molecules by the increase in temperature – much the same as long chain hydrocarbons can be 'cracked' commercially.

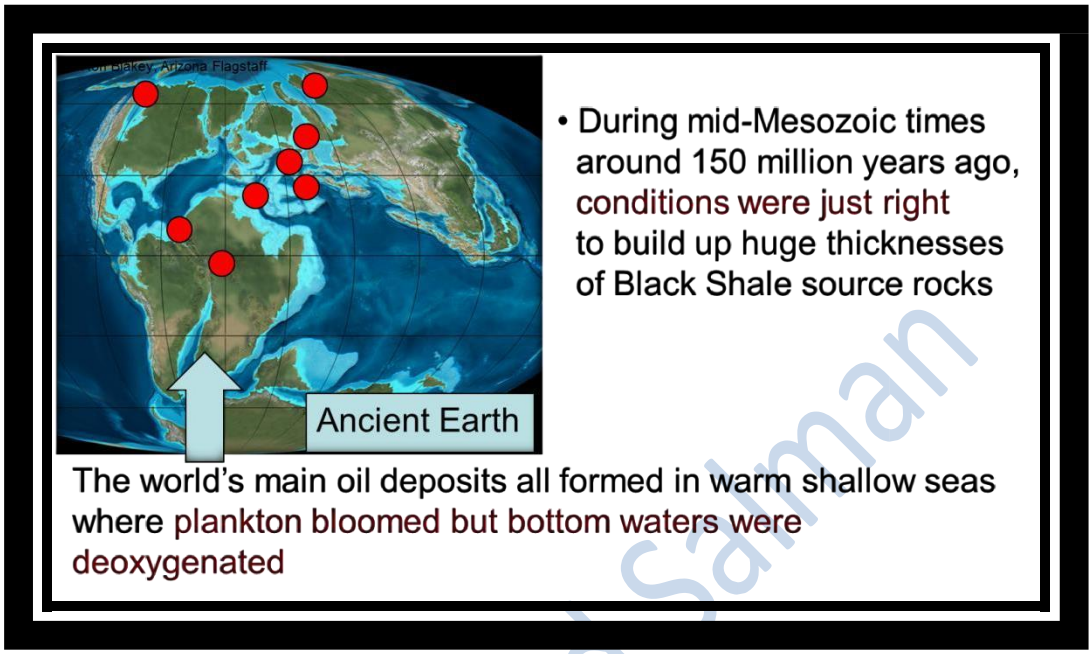
Origin (7): Migration

Migration and accumulation of oil and gas

The hot oil and gas does not stay in the Source Rock for long. As the hydrocarbons are less dense than the water in the source rocks that surround them, they gradually migrate upwards through the rock in much the same way that the less dense air bubbles of an underwater diver will rise through water.

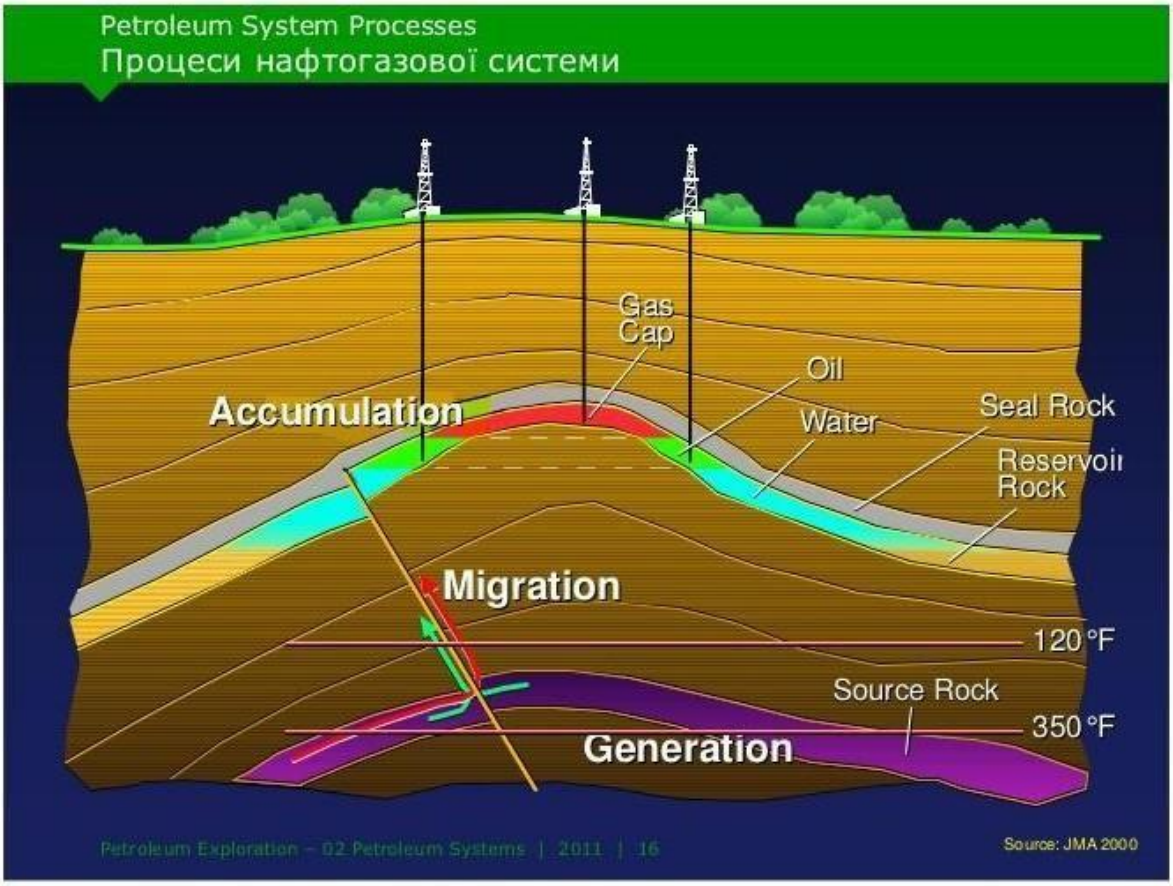
The migrating oil and gas may travel up through the spaces between the sand grains that make up the rock (called pores) or they may find their way up through cracks, fissures, and faults in the overlying rocks. As we will see when we look at oil exploration, eventually oil and gas get trapped in pockets of rock known as reservoirs.

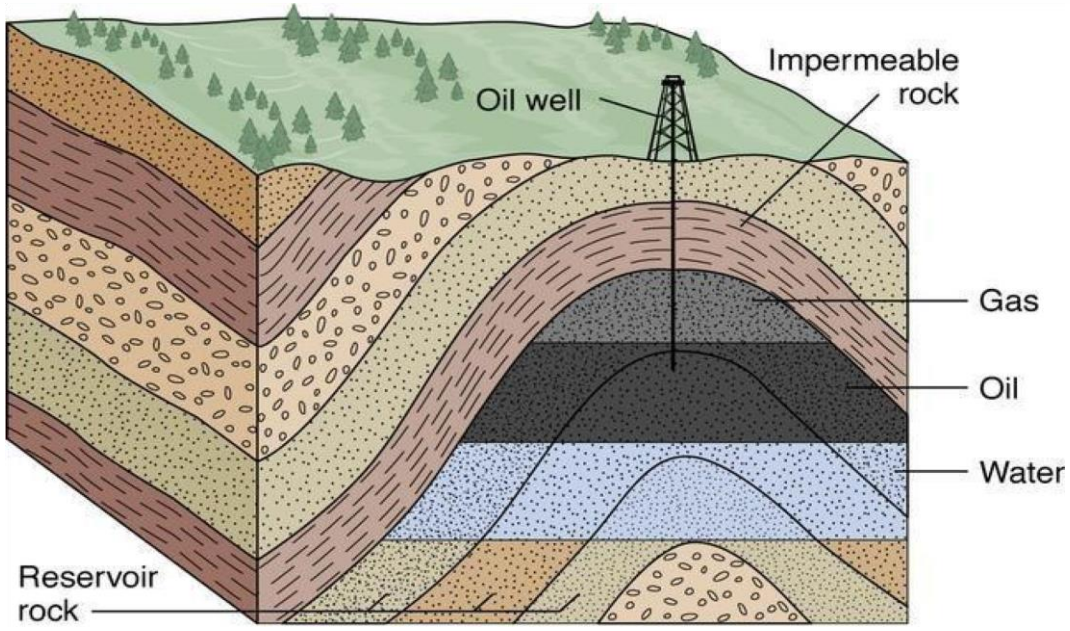




Origin (8): Ancient Earth

Most of the Source Rocks that gave rise to our present day oil and gas fields were formed in the middle of the Mesozoic Era about 150 million years ago. At that time conditions were just right to build up huge thicknesses of Black Shale. On the one hand, the oceans were unusually warm, promoting vast plankton blooms. On the other hand, oxygen was mostly absent on the ocean floors so most of the plankton that settled on the bottom accumulated. There were no animals around to eat it up. The map on the left hand side shows what the Earth looked like 150 million years ago. The red circles show where the world's main oil deposits were formed in warm, shallow, deoxygenated seas.


Petroleum System Processes
Процеси нафтогазової системи
Gas Cap
Oil
Water
Seal Rock
Reservoir Rock
Accumulation
Migration
120 °F
Source Rock
350 °F
Generation
Petroleum Exploration – 02 Petroleum Systems | 2011 | 16
Source: JMA 2000


Oil well
Impermeable rock
Gas
Oil
Water
Reservoir rock

Petroleum System

Petroleum system is group of elements and processes combined together to formed oil and gas . If absence anyone of these elements or processes, the petroleum system will be not active .

Petroleum System

Elements

1-Source Rock

2-Reservoir Rock

3- Migration Rout

4- Seal Rock

5-Traps

Processes

1-Generation

2-Migration

3-Acumelation

4-Pressivition

5-Timing

1-Source Rock

The term "Source Rock " is meant to be any rock that has the capability to generate and expel enough hydrocarbons to form an accumulation of oil and gas.

Type of source rock

1-Effective source rock : any sedimentary rock that has already generated and expelled hydrocarbons .

2-Possible source rock : any sedimentary rock whose source potential has not yet been evaluated , but which may have generated and expelled hydrocarbons .

3-Potential source rock : any immature sedimentary rock known to be capable of generated and expelled hydrocarbons if its level of thermal maturity were higher

petrophysical properties

petrophysical properties of source rock are :

1-Low density.

2-High sonic.

3-High neutron porosity.

4 –Very high gamma ray.

Organic matter in source rock

Source rocks are sediment contain sufficient organic matter which is basically derived from marine or lacustrine algae and land plants .

This organic matter contains chemical compounds which are preserved within sediments during deposition in reducing environment .

Factors influencing organic richness

1-Productivity : (many factors influencing productivity would include light intensity ,temperature ,carbonate supply ,and general water chemistry).

2-Preservation :(Three factors affect the Preservation of organic matter , the concentration and nature of oxidizing agents ,the type of organic matter deposited ,and the sediments –accumulation rate).

Kerogen

Kerogen is normally defined as that portion of the organic matter present in sedimentary rock that is insoluble in ordinary organic solvents. The soluble portion ,called bitumen .

Kerogen Types

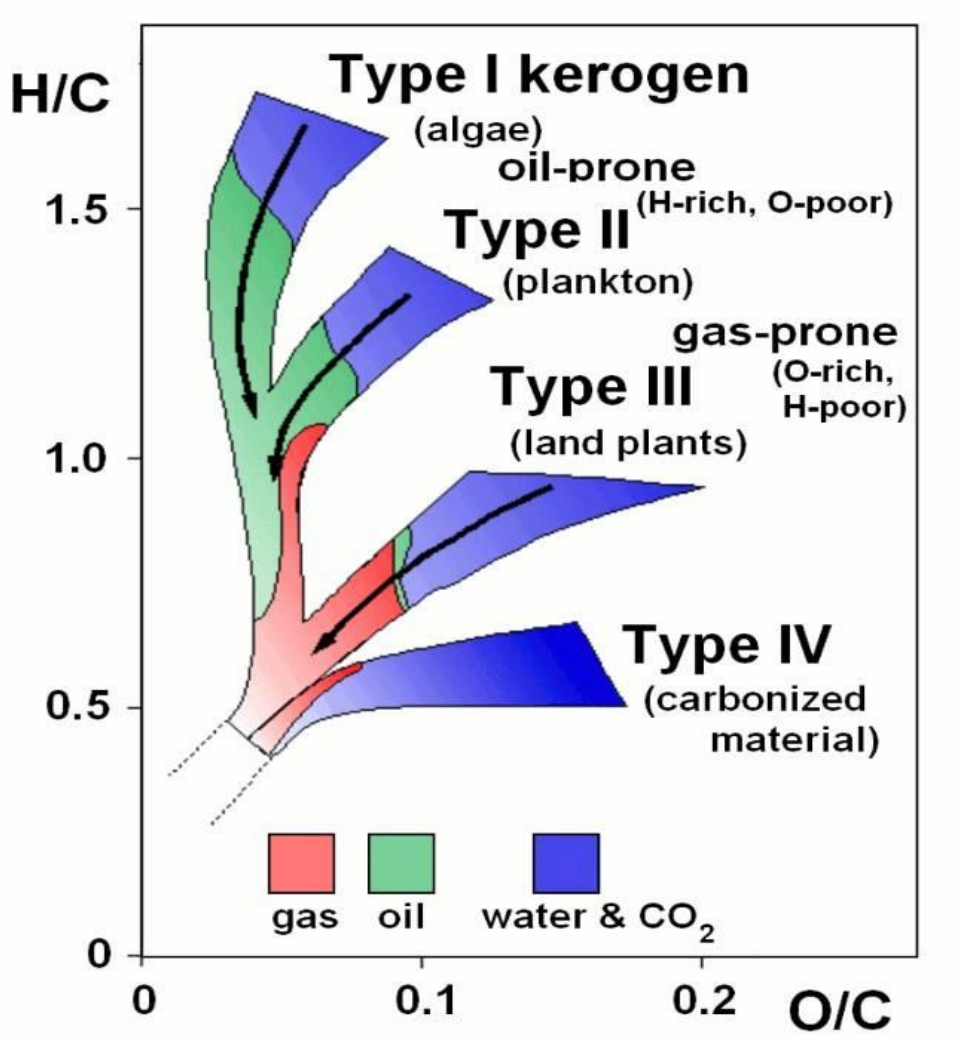
Kerogen (solid organic matter) has been classified to four kerogen types:

1-Kerogen Type I

2-Kerogen Type II

3-Kerogen Type III

4-Kerogen Type IV



General scheme of kerogen evaluation presented on Van Krevenles diagram

2- Reservoir Rock

Reservoir rock is a body of porous and permeable rock containing oil and gas through which fluid may move towards recovery opening under the pressure existing or that may be applied.

.- A petroleum reservoir consists of three essential elements.

1- The reservoir rock .
2- The pore space or void space .
3- The trap .

1-Reservoir rock

-The composition and texture of reservoir rock.

-The edges of the reservoir rock may coincide with the edges of the petroleum pool .

- The reservoir rock ,through extending through a large region ,my become a petroleum reservoir only at locally favorable areas.

2-The pore space or void space

-sometime called **reservoir space**

Is expressed as a fraction or percentage of total volume of the rock (for example 23%) And is called **porosity**

.The pore space is that portion of the reservoir rock that is available for the migration , accumulation ,and storage of petroleum .

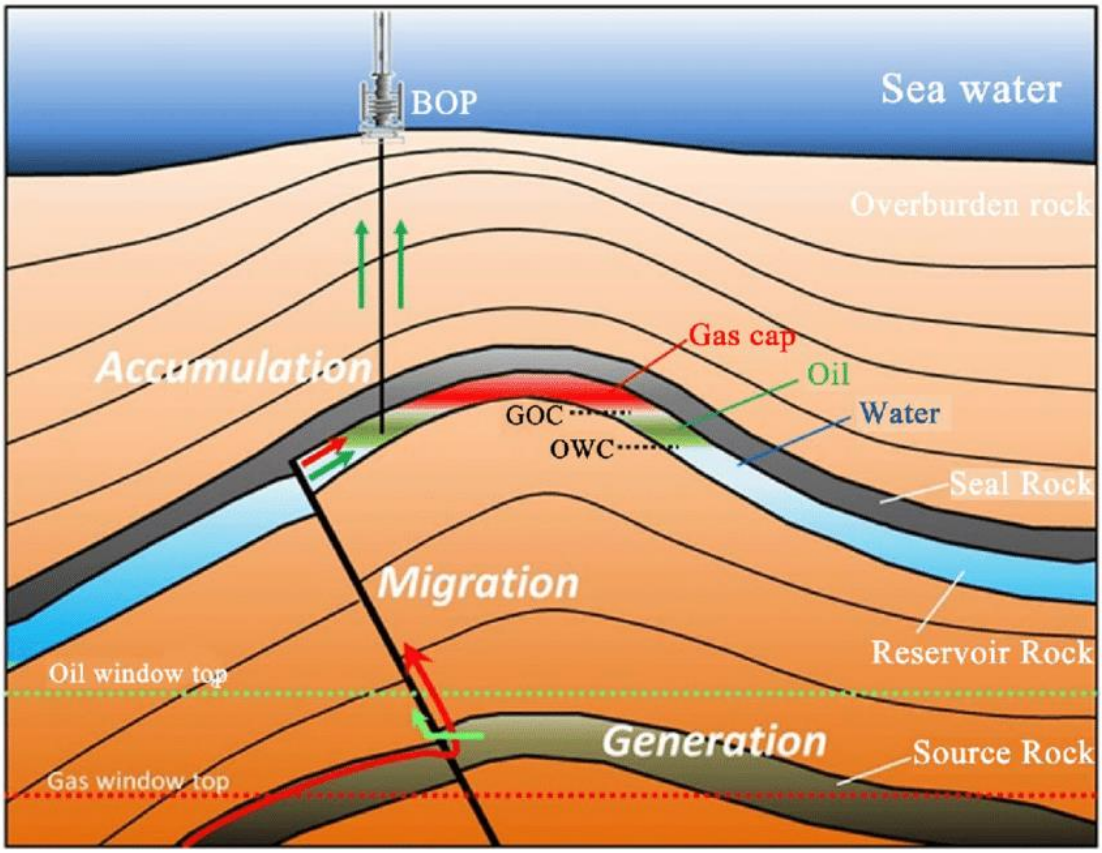
- The measure of the ease with which fluids may move through the interconnection pores of the rock is called **permeability** .

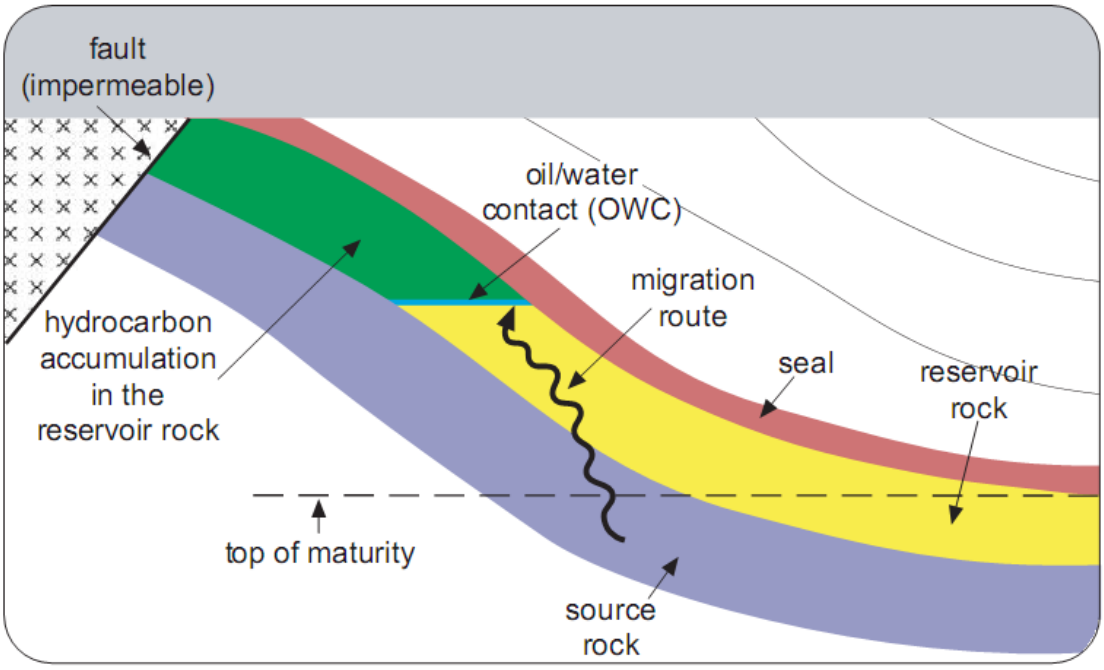
- Porosity and permeability are properties that depend on the presence of pore space.

- They are of special interest because they determine the capacity of the reservoir rock both to hold and yield its petroleum content .

3-Migration Route

Migration Route is a particulars ways or direction between grains where petroleum took place and migrate through pores from place near source rock to trap.




fault
(impermeable)
oil/water
contact (OWC)
migration
route
seal
reservoir
rock
hydrocarbon
accumulation
in the
reservoir rock
top of maturity
source
rock

4-Seal rock

A reservoir needs a cap rock which is impermeable cap rock where keeps the fluids trapped in the reservoir .

Some examples are (shale ,salt, anhydrite and zero-porosity carbonates).

5-The traps

Traps are formed by a wide variety of combination of stratigraphic and structural features of the rocks.

In practice the term **trap** usually means any combination of structure permeable and impermeable rocks that will keep oil and gas from escaping, either vertically or laterally, because of difference in pressure or in specific gravity.

Classification of traps

The classification divides the traps broadly into four basic traps.

1-Structural traps.

2-Stratigraphic traps.

3-Combination traps.

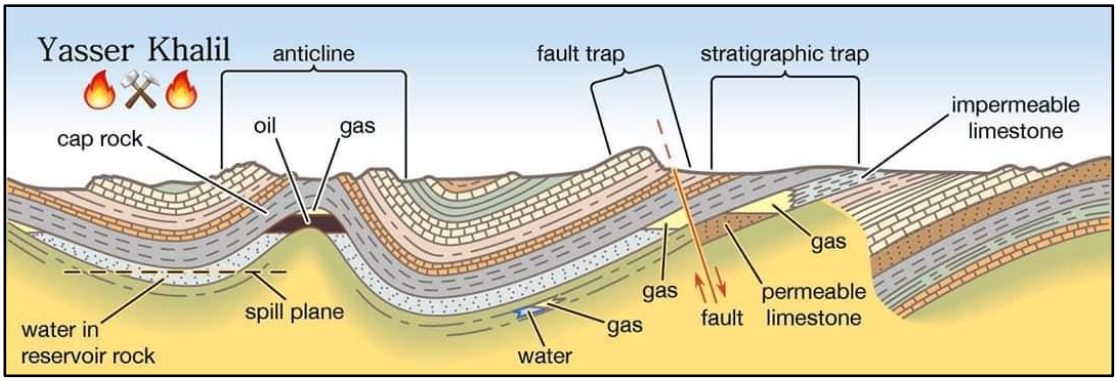
4-Hydrodynmic traps.

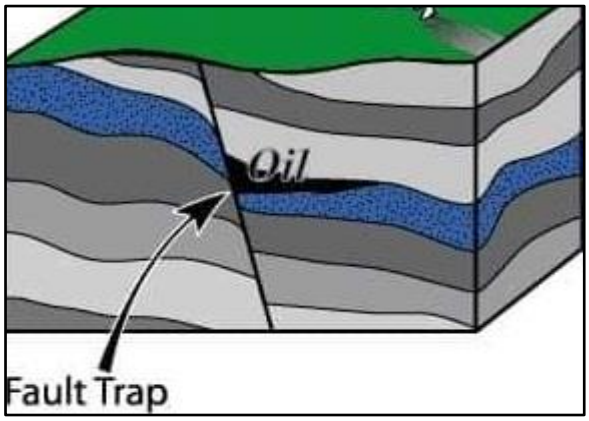
1-Structural traps

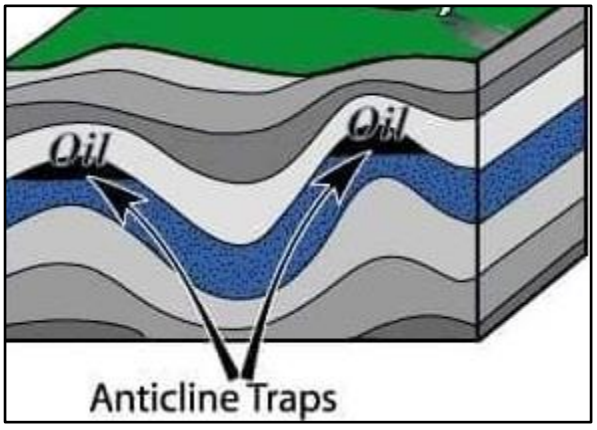
Traps that are formed mainly as a result of deformation, such as faulting and folding or both.

-It is the most apparent form mapping, and most readily located underground .

-So they are given the most help to the discovery of oil and gas.







2-Stratigraphic traps

Is a general term for stratigraphic traps that are result of lateral variation in lithology of the reservoir rock , or a break in its continuity .

-A permeable reservoir rock changes to an impermeable rock

- It is truncated by unconformity .

- Overlapped .

- changes along its bedding .

Stratigraphic traps may be divided into two general classes.

1-Primary stratigraphic traps.

2- Secondary stratigraphic traps.

1-Primary stratigraphic traps.

-Formed during the deposition of the rock.

-Include lenses, facies changes(pinch-out) , channel fillings, reefs.

2-Secondary stratigraphic traps.

-They are associated with unconformity.

-It might called unconformity traps.

-Have resulted from later causes.

-Such as solution and cementation.

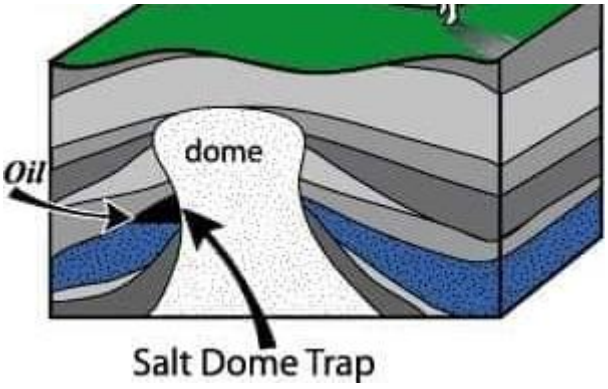
3-Combination traps.

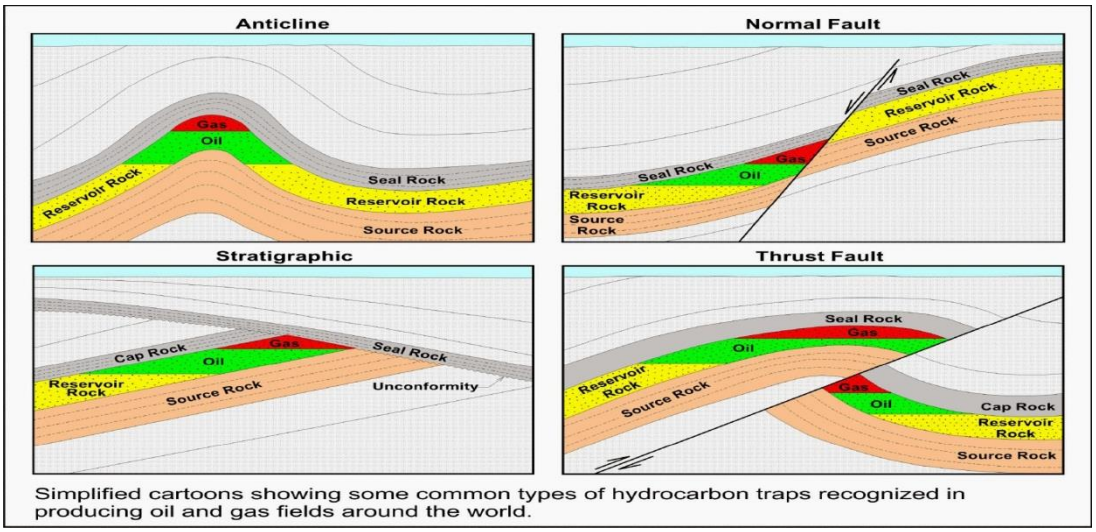
-The trap is formed partly by structural and partly by stratigraphic effects ,but not completely due to one of them.

-The stratigraphic element may have formed early ,during the deposition of the reservoir rock ,or later ,by subsequent local cementation, or by uplift , and unconformable overlap.

-The structure elements may be any kind of folding or faulting or both.

-One of most kind combination traps is salt domes traps.





Simplified cartoons showing some common types of hydrocarbon traps recognized in producing oil and gas fields around the world.

4- Hydrodynamic trap.

These traps is due to water flowing through the reservoir and holding the oil in places where it would not otherwise be trapped .

Petroleum system processes

1-Generation : Burial of source rock to temperature and pressure regime sufficient to convert organic matter into hydrocarbon .

2-Migration : Movement of hydrocarbon out of the source rock toward a reservoir rock.

Type of migration :

1-Primary migration: From the source rock to a porous rock ,this is a complex process and not fully understood.

It is limited to a few hundred meters.

2-Secondary migration : It is migrate the hydrocarbon along the porous rock to the trap.

-This occurs by buoyancy ,capillary pressure and hydrodynamics through continuous water-filled pore system.

-It can take place over large distances.

3-Accumulation :A volume of hydrocarbon migration into a trap faster than the trap leaks resulting in an accumulation .

4-Preservation : Hydrocarbon remains in reservoir and not altered by biodegradation or water-washing.

5-Timing : Trap forms before and during hydrocarbon migration.