

Petroleum Geology

INTRODUCTION



Al-Ayen University/ College of Petroleum Engineering

Dr. Abdulhussien Neamah Alattabi

PETROLEUM GEOLOGY

What is Petroleum geology?

Petroleum geology is the study of origin, occurrence, movement, accumulation, and exploration of hydrocarbon fuels. It refers to the specific set of geological disciplines that are applied to the search for hydrocarbons (oil exploration).

Sedimentary basin analysis

Petroleum geology is principally concerned with the

evaluation of seven key elements in sedimentary basins:

1-Source

2-Reservoir

3-Seal

4-Trap

5-Timing

6-Maturation

7-Migration.

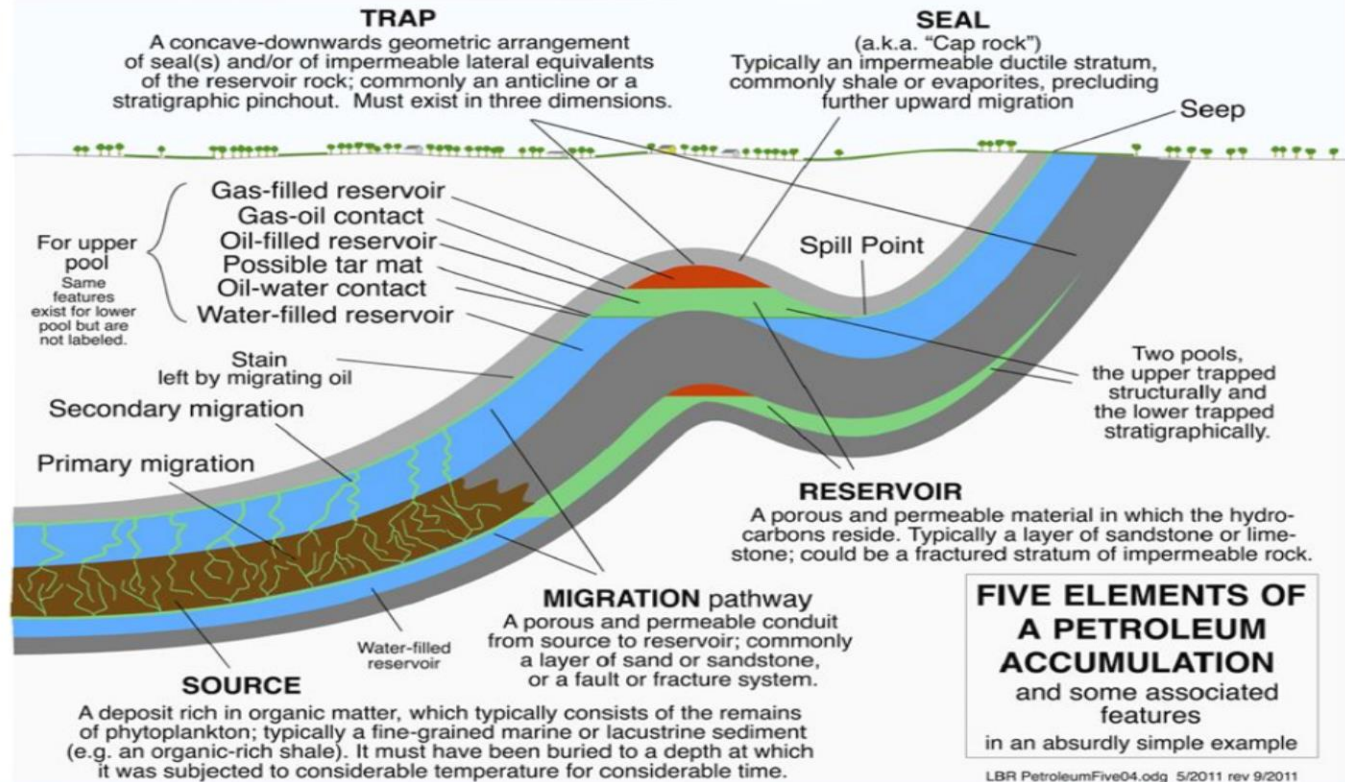


Fig.(1): Elements of Petroleum Accumulation

(1)Source Rocks

In petroleum geology, source rock is rock which has generated hydrocarbons or which could generate hydrocarbons.

Source rocks are one of the necessary elements of a working petroleum system.

They are organic-rich sediments that may have been deposited in a variety of environments including deep water marine, lacustrine and deltaic. Oil shale can be regarded as an organic-rich but immature source rock from which little or no oil has been generated and expelled. Subsurface source rock mapping methodologies make it possible to identify likely zones of petroleum occurrence in sedimentary basins as well as shale gas plays.

Kerogen:

kerogen. / (' kɛrədʒən) / noun. the solid organic material found in some rocks, such as oil shales, that produces hydrocarbons similar to petroleum when heated.

Kerogen is a waxy, insoluble organic substance that forms when organic shale is buried under several layers of sediment and is heated. If this kerogen is continually heated, it leads to the slow release of fossil fuels such as oil and natural gas, and also the non-fuel carbon compound graphite.



Fig,(2): Kerogen

Formation of Kerogen:

The formation of kerogen represents a major step in the formation of oil and natural gas, as kerogen serves as the source of these fossil fuels. For kerogen to form, dead

phytoplankton, zooplankton, algae, and bacteria must sink to the bottom of an ancient still water environment. After, this dead material must mix with inorganic, clay-like materials that enter these oceans from streams and rivers. This creates an organic-rich mud - which cannot be exposed to too much oxygen or else the organic matter within the mud is decomposed too quickly by bacteria. Before this organic matter is destroyed, it is buried by more sediment and lithifies (becomes sedimentary rock), creating organic shale.

If this shale is buried between 2 and 4 kilometers, its temperature increases due to its location in the Earth's interior. This increasing pressure and temperature of the shale finally transforms it into kerogene.

Bitumen:

Naturally occurring, inflammable organic matter formed from kerogen in the process of petroleum generation that is soluble in carbon bisulfide. Bitumen includes hydrocarbons such as asphalt and mineral wax. Typically solid or nearly so, brown or black, bitumen has a distinctive petroliferous odor. Laboratory dissolution with organic solvents allows determination of the amount of bitumen in samples, an assessment of source rock richness.

What are the difference between Kerogen and Bitumen?:

Kerogen is consumed during thermal maturation, whereas bitumen is an intermediary formed at low maturity from kerogen and consumed at higher maturities in formation of oil and gas. Bitumen relative to kerogen has higher aliphatic content, lower aromatic content, and lower abundance of oxygenated functions.

Types of Source Rocks

Source rocks are classified from the types of **kerogen** that they contain,

which in turn governs the type of hydrocarbons that will be generated:

- Type I source rocks are formed from algal remains deposited under **anoxic** conditions in deep lakes: they tend to generate waxy **crude oils** when submitted to **thermal stress** during deep burial.

- Type II source rocks are formed from marine **planktonic** and bacterial remains preserved under anoxic conditions in marine environments: they produce both oil and gas when **thermally cracked** during deep burial.

- Type III source rocks are formed from terrestrial plant material that has been decomposed by **bacteria** and **fungi** under oxic or sub-oxic conditions: they tend to generate mostly gas with associated light oils when thermally cracked during deep burial. Most coals and coaly shales are generally Type III source rocks.

Origin of oil

What are the different theories of origin of petroleum?

There are two different theories for the origin of petroleum; Organic and Inorganic origin.

1-Inorganic or Abiotic origin

States that hydrogen and carbon came together under great temperature and pressure, far below the earth's

surface and formed oil and gas where chemical reactions have occurred. oil and gas then seeped through porous rock to deposit in various natural underground traps. It has also excluded the hypothesis that petroleum is a finite substance. There are some different theories that describe the inorganic origin of petroleum which include:

a-Metal carbide theory

Developed by a Russian chemist and states that the deposition of petroleum is controlled by tectonic activities that occurred during the life of sedimentary rock. To explain his observations, he has put forth "metal carbide theory". Metal carbides deep in Earth reacted with water at high pressure and temperature to

form acetylene which condenses to heavier hydrocarbons.

Reaction equation is: $\text{CaC}_2 + \text{H}_2\text{O} = \text{C}_2\text{H}_2 + \text{Ca(OH)}_2$.

b-Volcanic theory

Involves outgassing of the mantle via volcanic activity or eruption.

c- Earthquake theory

Involves outgassing deep Earth's mantle via tectonic activities such as faults, and this is still happening till now.

d- Serpentinization theory

States that hydrocarbon is a by-product that came from a metamorphic transformation of the green dark Olivine mineral ,which was found in Earth's mantle`

Overwhelming evidences for inorganic origin of petroleum الأدله الدامغه على الأصل اللاعضوي للنفط

- **Geographical location:** most of hydrocarbon producing regions are located close to belts of tectonic activities.
- **Stability with depth:** Corresponding to what organic theory's supporters have admitted themselves; petroleum is a fossil fuel, and there has never been a real fossil found below 16000 feet. Nowadays, there is drilling for oil reservoirs

at 28000 feet or 30000 feet where there is no a fossil remains.

2- Organic origin

It is the most widely accepted. The oil and gas are formed from remains of prehistoric plants and animals. Remains of plants have been transformed to coal and animals to oil and gas. These remains were settled into seas and accumulated at the ocean floor and buried under several kilometers of sediments. Over a few milion years, the layers of the organic material were compressed under the weight of the sediments above them. The increase in pressure and temperature with the absence of oxygen changed the mud, sand, slit or sediments

into rock and organic matter into Kerogen. After further burial and heating, the kerogen transformed via cracking into petroleum and natural gas.^[3]

Overwhelming evidences for organic origin of petroleum

- Presence of brine (sea water) with petroleum.
- Petroleum is found only in association with sedimentary rocks. There is no petroleum associated with igneous or metamorphic rocks.
- Polarized light passing through all petroleum resources undergoes a rotation that is similar to all organic oils.
- Molecules in hydrocarbons are thought to be similar to that of the organic matter.

- The organic carbon found in plants is depleted into C13 due to photosynthesis process. In dead organic matter, it is further depleted due to radioactive decaying. The same depletion was found in petroleum and natural gas.

Conclusions:

The battle between organic and inorganic theories are still persistent till now. All the supporters from both sides were struggling to prove their theory. According to organic theory, petroleum is a finite substance formed from organisms decaying at several kilometers below the ground surface. On the other side, Inorganic origin supporters consider petroleum a self-regenerating substance produced

by the Earth itself with the assistance of chemical interactions occurring deep within the Earth. In other words, it is assumed that petroleum is not a finite substance as oil and gas didn't not run out till now. The most widely accepted one is the organic theory which defines the substantial conditions for the formation of petroleum such as: saturated soil, absence of oxygen and high pressure and temperature conditions. All these conditions contribute to the decay of organic matters which then is transformed into kerogen forming a source rock.

•

