Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering

Department

Properties of Petroleum & Natural Gas

Third Class

Lecture 1

By

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General Overview (Petroleum)

- The word petroleum originated from the Latin words, Petra, meaning rock and oleum, meaning oil. Literally it means 'Rock Oil,' and can also be defined as a non-renewable fossil fuel or oil that is found underground. This is any naturally-occurring flammable mixture of hydrocarbons found in geological formations such as rock strata. Technically, the term petroleum refers to describe any solid, liquid or gaseous hydrocarbons. It's also known as 'crude oil' or 'mineral oil.
- Petroleum is a fossilised mass that has accumulated below the earth's surface from time immemorial. Raw petroleum is known as crude (petroleum) oil or mineral oil.
- Petroleum is one of the most important substances consumed by man at present time. It is used as a main source of energy for industry, heating, and transportation and it also provides the raw materials for the petrochemical plants to produce polymers, plastics, and many other products.
- The main elements of petroleum are carbon (C) and hydrogen (H) and some small quantities of sulfur (S), nitrogen (N), and oxygen (O).
- Petroleum is a mixture of various organic substances and is the source of hydrocarbons, such as methane, ethane, propane, butane, pentane, and various other paraffinic, naphthenic, and aromatic hydrocarbons, the building blocks of today's organic industry.
- Petroleum contains small quantities of non-hydrocarbon components such as H_2S and traces amounts of metals such as nickel, iron, copper, cobalt and vanadium.
- Petroleum is found in the form of gas and /or liquid phases **in porous rock structures** (sedimentary basins).
- Petroleum is a complex mixture of hydrocarbons that occur in the sedimentary rocks in the form of gases (natural gas), liquids (crude oil), semisolids (bitumen), or solids (wax or asphaltite). Liquid fuels are normally produced from liquid hydrocarbons, although conversion of nonliquid hydrocarbons such as coal, oil shale, and natural gas to liquid fuels is being investigated.
- Liquid petroleum is also simply called oil. Hydrocarbon gases in a reservoir are called a natural gas or simply a gas. An underground reservoir that contains hydrocarbons is called petroleum reservoir and its hydrocarbon contents that can be recovered through a producing well is called

reservoir fluid. Reservoir fluids in the reservoirs are usually in contact with water in porous media conditions and because they are lighter than water, they stay above the water level under natural conditions.

- There are several theories on the formation of petroleum. It is generally believed that petroleum is derived from aquatic plants and animals through conversion of organic compounds into hydrocarbons. These animals and plants under aquatic conditions have converted inorganic compounds dissolved in water (such as carbon dioxide) to organic compounds through the energy provided by the sun.
- Conversion of organic matters into petroleum is called maturation. The most important factors in the conversion of organic compounds to petroleum hydrocarbons are (1) heat and pressure, (2) radioactive rays, such as gamma rays, and (3) catalytic reactions. Vanadiumand nickel-type catalysts are the most effective catalysts in the formation of petroleum. For this reason some of these metals may be found in small quantities in petroleum fluids. In summary, the following steps are required for the formation of hydrocarbons: a source of organic material and the process to convert.
- The hydrocarbon processing industry is basically divided into three distinct activities — petroleum production, petroleum refining, and petrochemical manufacture.
- Various petroleum products, such as gaseous and liquid fuels, lubricating oil, solvents, asphalts, waxes, and coke, are derived from refining crude oil. Many lighter hydrocarbons and other organic chemicals are synthesised by thermal and catalytic treatments of these hydrocarbons.
- Refineries produce cooking gas (liquified petroleum gas or LPG), motor spirit (also known as petrol or gasoline), naphtha, kerosene, aviation turbine fuel (ATF), high speed diesel (HSD), lubricating base oils, wax, coke, bitumen (or asphalt), etc., which are mostly a mixture of various hydrocarbons (the organic compounds made of carbon and hydrogen as the major constituent elements).

Differences between Crude Oil, Petroleum Products and Petroleum

- Crude oil- Mixture of hydrocarbons existing as liquid in natural underground reservoirs and remain liquid during extraction.
- Petroleum products- Produced from the processing of crude oil at petroleum refineries and extraction of liquid hydrocarbons at natural gas processing plants.
- Petroleum- refers to the broad category that includes both crude oil and petroleum products.

Occurrence of Petroleum

- Petroleum occurs in the earth's crust, in all possible states and varies in color from light brown to dark brown or black, exhibiting luminescence in some cases. It is a mixture of various hydrocarbons, of homologous series namely paraffins, napthenes and aromatics.
- The final result is a black viscous product of composition:

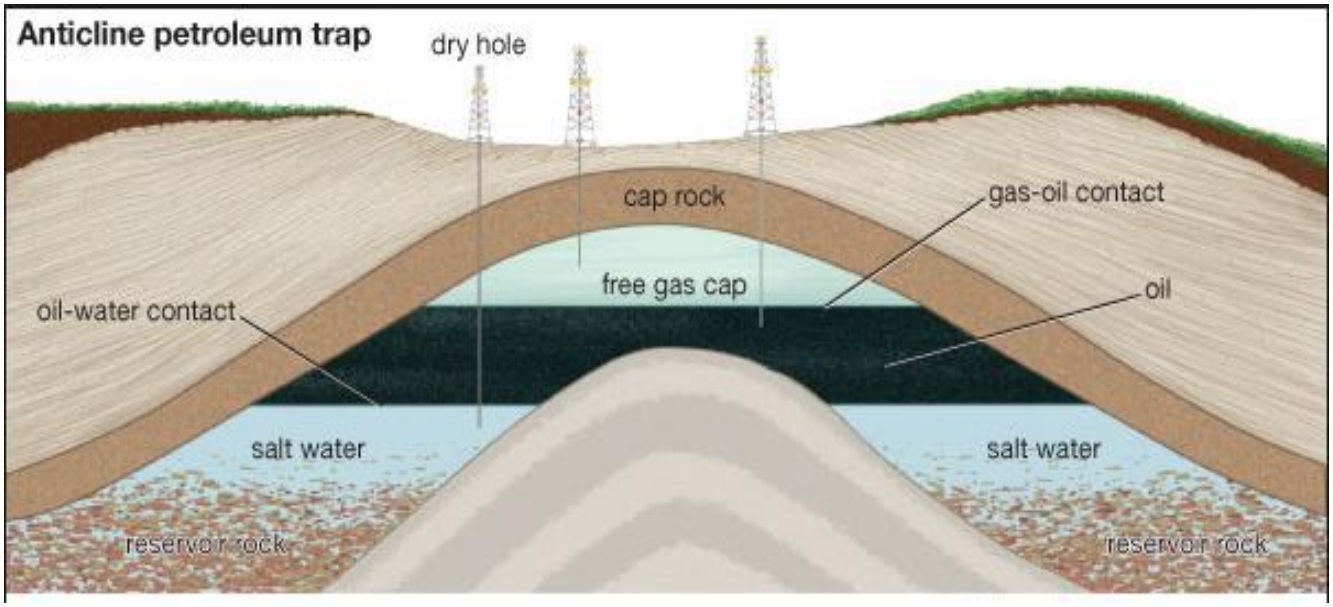
Carbon	80 to 89%
Hydrogen	12 to 14%
Nitrogen	0.3 to 1 %
Sulphur	0.3 to 3%
Oxygen	2 to 3%

Petroleum Formation

There are basically two theories explaining the origin of oil,

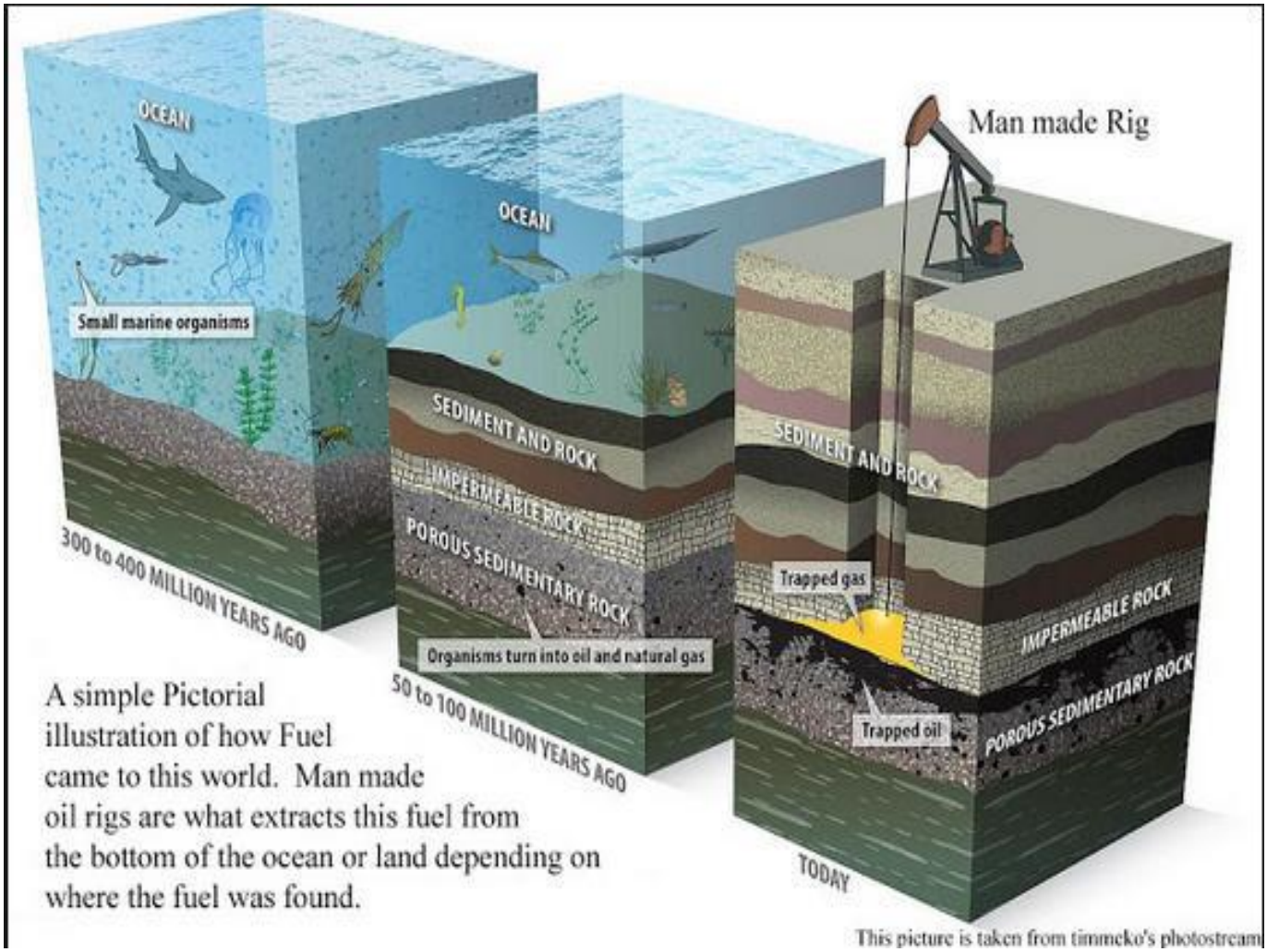
1-Organic Theory (Biotic Theory)

- Oil developed millions of years from organic material remains of dead plants and animals (algae and planktons).
- The dead organisms sank to the bottom of water bodies (seas and lakes), where the environment tends to be anaerobic.
- They accumulated in the mud on the beds of the water bodies, partially decomposed.
- Sediment deposition on the bed of the water body, burying and compressing the organic matter under its weight.
- Increase in temperatures (100-160°C) and pressures resulted due to continued sediment deposition.
- With time the conditions broke down the organic compounds into shorter hydrocarbon chains, forming oil and natural gas.
- Oil and natural gas flowed from the source rock, accumulating in thicker more porous rock called a reservoir rock.
- Earth movements (faulting, folding) trapped the oil and natural gas in the reservoir rock between layers of impermeable rock or cap rock also called an oil trap.



Conditions necessary for biotic on formation

- Deep burial under sand and mud.
- Pressure cooking.
- Hydrocarbon migration from the source to the reservoir rock.
- Impermeable rock to trap the oil.



2- Inorganic Theory (Abiogenic/Abiotic Theory)

- This hypothesis of petroleum origin without biology was first proposed in 16th century by Georg Agricola, then in 19th century by Alexander (Prussian geographer), Dmitri (Russian chemist), Marceline (French chemist) and re-defined in 20th century by Cornell University physicist, Thomas Gold.
- Supporters of this hypothesis argued that hydrocarbons existed at the formation of the solar system and were abundant in other system and were abundant in other planets e.g. Saturn, Jupiter.
- The theory argued that petroleum originated from limitless pools of liquid primordial hydrocarbons at great depths in the earth.
- These carbon-bearing fluids migrated upward from the mantle where they slowly replenish the reservoirs that conventional oil drillers tap.

Other hypothesis arose as a result of the Abiotic theory. These include,

i. Deep seated terrestrial hypothesis.

Proposed by Dmitri Mendeleev, he postulated that metallic carbides deep within the earth reacted with water at high temps, forming acetylene.

$CaC_2(s)+2H_2O$ ------> $Ca(OH)_2(s)+C_2H_2(g)$

ii. Extra terrestrial hypothesis.

Proposed by Sokoloff, he based a cosmic origin to petroleum origin. He postulated that hydrocarbons precipitated as rain from original nebular matter from which the solar system formed.