# THE ORIGIN OF OIL AND NATURAL GAS

## PETROLEUM

Coal, oil and natural gas are collectively known as fossil fuels stemming from their origins of once-living organisms. To meet energy demands over the past 200 years, humans have required to increase their extraction of fossil fuels and look to alternative fuels such as uranium. We live in a society where burning hydrocarbons are the mainstream choice for fuel and products are heavily dependent on the use of petroleum.

**Petroleum includes natural gas (gas), crude oil liquid) and asphalt (solid).** Petroleum is not solely used for the purpose of fuel but is also part of the multi-million-pound **petrochemical industry**: developing, synthetic fibres for clothing, paints, plastics, synthetic rubber, pharmaceuticals and fertilisers.

Petroleum is a non-renewable resource meaning that it will not be replenished in the foreseeable future/human timescale. For every new barrel discovered, we consume barrels and so the price of petroleum has been steadily rising and oil production will peak anywhere between now and 2030.

### Key Definitions

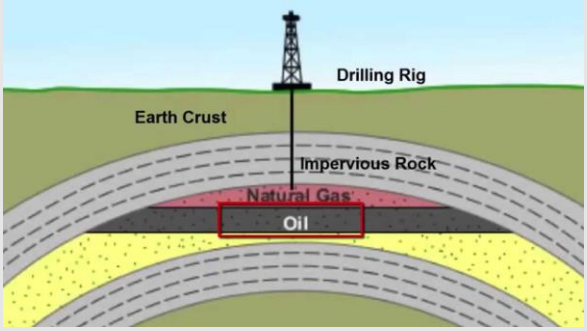
- **A source rock** is an organic-rich rock of mudstone or shale containing abundant plankton hat formed in low-energy, anoxic, marine environments.
- **The maturation process** is where plankton is converted to petroleum by the effects of temperature and pressure during burial (diagenesis).
- **Migration** describes the movement of petroleum from a source rock to a reservoir rock.
- **A reservoir rock** is highly porous and permeable and so is capable of storing and yielding significant amounts of petroleum.
- **The cap rock** is an impermeable rock that lays above the reservoir rock and prevents further upward migration of petroleum.
- **A trap** is a geological situation that constraints petroleum in one place.

*Natural gas and oil rise up within a reservoir rock because these substances are less dense than the water in the pore spaces (density of the rock as nothing to do with the migration process).*

## REQUIREMENTS FOR THE FORMATION AND ACCUMULATION OF OIL AND NATURAL GAS

Oil and natural gas originating in sedimentary basins. For an economically viable extraction we need:

- A source rock
- Maturation
- Migration
- A reservoir rock
- A cap rock
- A trap




### Environment of depositional source rock

Microscopic organisms called **plankton** that lived millions of years ago, **floating freely** through the surfaces of the ocean, died and gently sank through the water column to accumulate on the seafloor. The environment of deposition had to be **low in energy and conditions were anoxic** (lacking in oxygen) so the **plankton was no decayed or eaten by scavengers**. Once on the seabed**, anaerobic bacteria** would partially decay the plankton to produce an organic mud called **Sapropel**.

Burial in fine-grained sediment results in the formation of an **organic-rich sediment** called a source rock (a black oil **shale or mudstone**).

***Fine-grained*** → *low energy conditions of deposition*
***Dark colouring*** → *high organic (carbon) content*

## Maturation of petroleum

During maturation, the source rock, **sapropel,** is buried further and is subjected to compaction and the increasing geothermal gradient. This gradually alters sapropel into a **mixture called kerogen**.

**Kerogen** is the mixture of organic compounds carbon, hydrogen, oxygen, nitrogen and sulphur.

Petroleum forms between temperatures of $50^0$C to $200^0$C - this is called **the `oil window'**.

- **Below $50^0$C**, **biogenic gas** will form but is usually lost due to the shallow burial that this occurs at.
- The majority of **oil** forms within the range of **$50^0$C to $100^0$C.**
- **Natural gas (mainly methane**), forms between **$100^0$C and $200^0$C**
- **Above $200^0$C**, **denatures** most hydrocarbons – destroying them

## Migration of petroleum

Once formed, the petroleum undergoes migration from its source rock to a reservoir rock. Factors affecting the rate of this are as follows:

1. **The permeability** of the rocks – there must be permeable rocks to act as transfer route between the source and reservoir rocks.
2. **Pressure** – oil and natural gas will usually migrate down the pressure gradient from high pressure to low pressure. This is usually in an upward direction but sometimes is down.
3. **Density differences** – Oil and natural gas are less dense than water (due to weaker interactions between molecules) so will percolate up through pore spaces containing water until they reach an impermeable cap rock or reach the surface.
4. **The viscosity of the oil** – the higher the temperature of the oil, the lower the viscosity and so the easier it will flow.

## Reservoir rock

A reservoir rock must have a **high enough porosity and permeability** to both store significant amounts of petroleum and to allow oil and natural gas to migrate into it and then be extracted out from it. Hence, the properties of a reservoir rock for petroleum are the same as that for a reservoir for water.

***Suitable rocks include:*** *poorly cemented sandstones, most limestones and fracture chalk.*

## Cap rock

This acts as an impermeable layer that overlays the reservoir rock. The cap rock **prevents further upwards migration** of oil and natural gas, which would otherwise eventually from **oil seeps and tar pits** on the surface. Suitable cap rocks include fine-grained sedimentary rocks such as **clay, mudstone and shale** and **crystalline rocks such as evaporates**.

## Trap rock

The final requirement for the accumulation of oil and natural gas is the presence of a trap.