FOSSIL FUELS ARE THEY DINOSAURS?

Ian J. McKay
School of Geosciences
University of the Witwatersrand
Combustion

\[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]
Mainly Carbon and Hydrogen
Also others like Oxygen and Sulphur
## Hydrocarbons

### Periodic Table of Elements

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Design and Interface Copyright © 1997 Michael Dayah (michael@dayah.com). http://www.ptable.com/
CARBON
IDENTIFY THE HYDROCARBONS

- A Used engine oil
- B New engine oil
- C Peat
- D Tar
- E Charcoal
- F Coke
- G Anthracite
- H Coal
Examples are:

- Coal
- Natural Gas
- Oil
FOSSIL FUEL FACTS

• Rotting plant material becomes peat.
• Peat is buried and subject to high pressures and temperatures.
• Peat becomes lignite.
• Lignite becomes bituminous coal.
• Bituminous coal becomes anthracite.
260 million years ago South Africa was covered with vast swamps
MODERN SWAMPS
WHERE WERE THEY FOUND?

Cargonian Highlands

KAROO SEA
Deep water trough

SOUTH AMERICA

Cape Fold Belt mountain range

EAST ANTARCTICA

FALKLAND PLATEAU
PRESERVED AS FOSSILS

Ferns

Glossopteris

Horse tails
Over millions of years plants in the coal swamps died and were buried underwater with no oxygen.

The dead plant material did not decompose forming peat.

Burial of the peat created heat and pressure resulting in the peat being turned into coal.

In South Africa peat is found in wetlands where it is protected.

In the Northern Hemisphere peat is more common.

Peat is can be burned or used as a potting soil, it is also used to grow mushrooms.
Lignite or brown coal forms when peat is altered by relatively low temperatures and pressures over a long period of time.

Lignite may still contain unaltered plant material.

Fresh Lignite has a high moisture content (up to 66%) content and a relatively low carbon content (20 – 35%).

Lignite contains many substances (volatiles) which turn into gas or smoke when burnt.

We do not burn lignite in South Africa, but in other parts of the world it is burned in power stations.
Bituminous coal is formed when lignite is subject to high pressures and temperatures.

Bitumen is a type a sticky black tar-like substance.

Bituminous coal is 60% to 80% carbon, together with substances like water, hydrogen and sulphur.

Bituminous coal is the most common type of coal in South Africa. It is used for heating, cooking and in power stations.

The high sulphur content of this coal can cause acid rain. Power stations need to “scrub” their waste gases to get rid of the sulphur.
Anthracite is formed when bituminous coal is subject to temperatures of between 150°C and 200°C.

Anthracite is a type of metamorphic rock.

It is harder and shinier than ordinary coal.

Anthracite contains between 92 and 98% carbon. It produces hardly any smoke and can burn for days (unlike ordinary coal which burns out in hours).

Anthracite is too expensive for power stations and is preferred for domestic heating and cooking because it is clean burning.
Coke is formed by heating low Sulphur bituminous coal in the absence of air at a temperature as high as 2000°C.

Coke burns cleanly at high temperatures.

Coke is specially useful in furnaces in the iron industry where it is used to reduce iron ore ($\text{Fe}_2\text{O}_3$) into iron.

$$2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$$
How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock. Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.
Oil is formed from fossilized plankton.

A drop of Ocean water contains thousands upon thousands of tiny creatures called plankton which include:

- Protists (e.g. copepods and algae including diatoms).
- Larvae of jellyfish, starfish, sea-cucumbers and other animals.

These tiny creatures die and form a thick sludge on the bottom of the ocean.

Diatoms- can form a thick clay called diatomite which is used in toothpaste.

The dead plankton sludge is buried and heated to form oil and gas.
Huge drilling rigs that can drill through thousands of metres of sediments are needed to drill for oil.

The drill rigs can be found on land or on floating platforms at sea.

Once the drillers have found oil they pump it out with special pumps.
Oil pumped straight out of the ground is called **crude oil**.

Crude oil is a smelly mixture of tar, oil, benzene and other substances including sulphur.

When an oil drill strikes oil the crude oil may come gushing out, this is called a blowout and can be very dangerous.
NATURAL GAS
METHANE
A n oil refinery is a huge factory where crude oil is converted into other products like:

- Tar (Bitumen)
- Wax
- Diesel
- Petrol
- Motor car oil
- Gas

The crude oil here comes from the Engen refinery in Durban.
In an oil refinery a huge fractional distillation column is used to separate the crude oil into different parts:

- At lower temperatures (20°C) gas (LPG) separates.
- At 150°C petrol forms.
- Next at 200°C paraffin (kerosene) separates.
- At 300°C Diesel forms.
- At 370°C motor car oil separates.
- At 400°C Wax and road tar separate out.
- The products of crude oil can be turned in many types of chemicals and plastics.
Since 1955 Sasol has had a factory that can turn coal into oil.

Coal is heated with oxygen and steam under pressure to make carbon monoxide, hydrogen and methane gas.

The gases are passed over an iron based catalyst to create:
- LPG (Liquid Petroleum Gas), petrol, diesel, paraffin, motor car oil, waxes, alcohol and acetone

Sasol can also turn natural gas into fuels.

Using natural gas and coal as a starting point Sasol produces over 300 types of chemical and many types of plastic.
IDENTIFY THE HYDROCARBONS

- A
- B
- C
- D
- E
- F
- G
- H
Fossil fuels are non-renewable resources. They took millions of years to form and once we have used them up they will be gone. It has been estimated that we have 35 years of oil left, 37 years of gas left and 105 years of coal. Calculating how long it will take to use up reserves of fossil fuel is complex because new reserves are being found as are new ways of extracting it.
THE GREENHOUSE EFFECT
THE MOON
In 2006 humans produced 29,195.42 million metric tons of carbon dioxide from use of fossil fuels.

It took millions of years for nature to take carbon dioxide out of the air and to store it in the Earth in the form of fossil fuels.

Humans are releasing it back into the air in only a few hundred years.

Increased concentrations of carbon dioxide together with other gases like methane are responsible for enhancing global warming.

Burning of fossil fuels produces many other pollutants.
BEFORE GLOBAL WARMING

$\text{CO}_2$

15.5 °C

$\text{CO}_2$

Cool

$\text{CO}_2$
With Global Warming

$\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2$

$\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2\quad\text{CO}_2$

16.5 °C

Warm
Carbon Dioxide at Mauna Loa, Hawaii
INCREASE IN TEMPERATURE

Global Temperatures

- Annual Average
- Five Year Average

Temperature Anomaly (°C)

1860 1880 1900 1920 1940 1960 1980 2000
VOSTOK ICE CORE
CO2 AND TEMP 400 000 YEARS

Temperature and CO₂ concentration in the atmosphere over the past 400 000 years (from the Vostok ice core)

Milankovitch Cycles

- Eccentricity
- Obliquity
- Precession
% of O₂ and CO₂ over time

The graph shows the percentage of O₂ and CO₂ over time (Ma). The x-axis represents time in Ma, and the y-axis represents percentage. The graph illustrates the fluctuations in the percentage of O₂ and CO₂ over geological time, with a significant increase during the Paleozoic era (Permian period).
Melting Ice Caps
High Sea levels
More extreme weather:
  • Hurricanes
  • Droughts
  • Storms
Sustainable/small carbon footprint

Practical

Not Practical

Not sustainable/ big carbon footprint