PRIMARY EARTH SCIENCE TEACHING

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FOSSIL FUELS 2

Oil: Formation, Production, Distribution and Uses

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Introduction

Following on from our look at coal in the previous issue, we now investigate possibly the world's most important fuel - oil. Oil is another fossil fuel which contains energy trapped by living organisms millions of years ago and whose remains have been converted to a combustible fuel over that time. These burnable properties make it an extremely useful, valuable and versatile resource, especially as it is generally in liquid form. Its geographical distribution will also be considered after first looking at its formation, methods of recovery and some of its uses. Some keywords are underlined and can be used as the focus for more in depth research, to form the basis of a glossary or to aid the finding of information and images during internet research.

What is oil?

Oil, or petroleum, is a liquid hydrocarbon of variable composition and quality, which is found in certain porous sedimentary rock formations. In its unrefined state it is known as crude oil.

How did oil form?

Microscopic organisms, especially planktonic sea-algae and bacteria, absorbed energy from the sun during their lives in the seas, lakes and swamps, which covered much of the Earth millions of years ago, and stored this energy as carbon. When these organisms died, they sank to the bottom where they were mixed with and covered by sediments. Many such organisms could have decayed quite quickly, however if large quantities of dead organic material accumulated on the muddy beds at the bottom of sheltered seas, lakes or swamps, any bacteria would soon use up the limited oxygen present. Without oxygen normal decay cannot take place so organisms are preserved. These preserved organisms mixed with the muds and together they eventually became the source rocks for the formation of oil. These organic-rich muds became buried by the further accumulation of sedimentary deposits and were then 'cooked' slowly by pressure and heat, over millions of years, turning them into oil and/or gas. Whether oil or gas formed generally depended upon the depth of burial, with oil being formed at shallower depths.

The heat and pressure deep inside the Earth's crust causes the various constituents of the dead organisms, such as fat, wax and cellulose (cell walls or plant 'skin'), to join together forming a dark substance called kerogen. As the source rock continues to heat up, the kerogen starts to release long hydrocarbon chains which form thick, waxy heavy oil. As the temperature increases it releases shorter hydrocarbon chains which form light oil and eventually gas. This initial generation is followed by these oils moving away, or migrating, from the source rock.

Oil migrates through permeable rocks, such as sandstone, which have cracks and connecting pore spaces (like sponge) between the rock particles allowing the flow of fluids through them. As oil and gas are not as dense as rock or water they tend to migrate upwards, dispersing water on the way. This movement is very slow and it may take millions of years for the oil to travel just a few kilometres. Although this migration brings oil to the Earth's surface in some place, it is more usual for the oil to become trapped in permeable reservoir rocks where these rocks are capped, covered, by impermeable rocks such as clays or salt, which act as seals. Oil collects in large quantities in rocks in areas where there is a suitable cap rock which is also domed in such a way to provide an enclosed, upturned basin-shaped trap. See figure 1 overleaf.

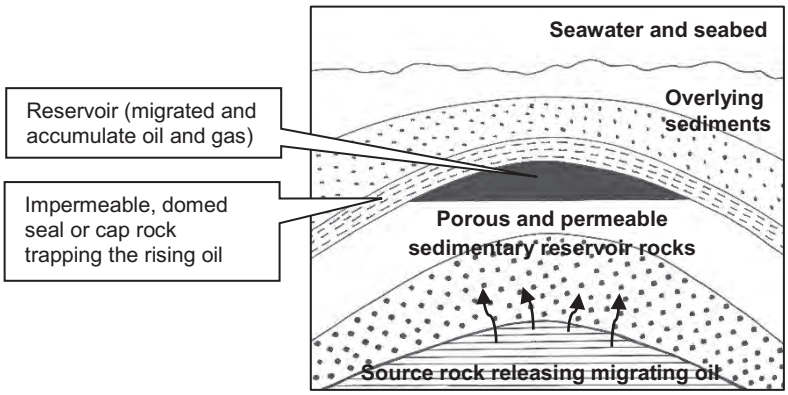

Figure 1 The migrating oil collects in the highest part of reservoir. Gas may bubble out of the oil and form a gas cap at the highest point.

Methods of Oil Recovery and Production

Finding oil trapped deep underground is a very complicated process. The oil companies need to find the right source rock, reservoir rock and entrapment area – the ideal conditions. Such surveys need detailed knowledge of geology and the best places to look; a lot of very expensive and sensitive equipment, including satellite imagery and ships, from which extensive seismic surveys are conducted; the amount of oil needs to be estimated and calculations made about how easy or difficult, cost effective, it is to access and recover the oil.

Once a prospective oil reservoir has been selected, suitable drilling rigs are set-up. These vary considerably in size and construction, depending upon where the site is, such as inland, shallow sea or deep sea location. A great deal of work needs to be done to prepare and safeguard the area surrounding any drilling site before rigs can be built, wells drilled and extraction can begin, which all adds to the huge costs involved in recovering oil.

Pressure is the driving force in oil recovery. The oil is under very high pressure underground but pressure is low at the Earth's surface. The low surface pressure is effectively transferred down the well and this low-pressure column intercepts the high-pressure reservoir allowing the highly-pressured oil to escape up the well, helped by the expansion of any gas lying above the oil. This upward movement and removal of oil from the reservoir creates space within reservoir area so more oil migrates into the reservoir, helped by being pushed up by the inflow of water, and replaces that which has been removed. This is known as reservoir drive.

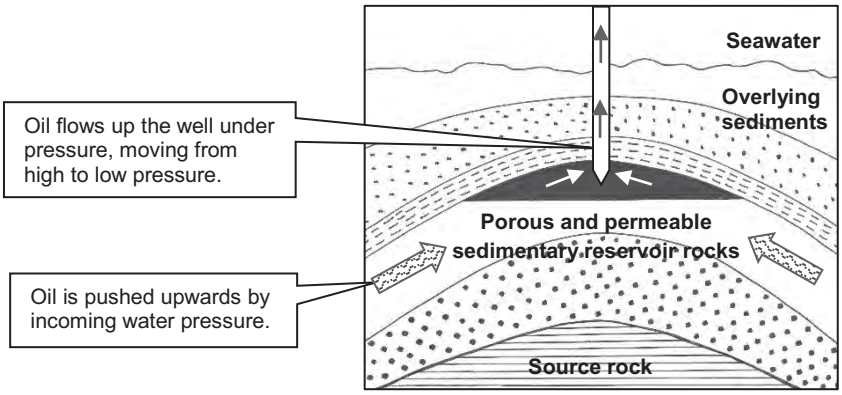

Figure 2 Reservoir drive, showing the flow of fluids during drilling.

Research Activity: Look on the internet for pictures and diagrams of different types of drilling rigs such as a Land Rig, Inland Barge, Jack-up Rig, Drill Ship and a Semi-submersible Rig.

Practical Activity: Simulate oil flowing up a well with this quick and easy investigation into how fluids can flow upward through narrow tubes when driven by pressure. Work in pairs.

Equipment: Large bowl, bottle of fizzy drink, a plastic drinking straw, plasticine or Blue Tac.

Method: Stand the bottle in the empty bowl. Wrap enough plasticine near the top of the straw to plug the bottle when inserted (measure first to stop straw touching bottom of bottle). With your finger sealing the straw top, plunge it into the bottle of drink until the top of the bottle is sealed, then release your finger. Bubbles of gas should rise up the straw and flow out at the top bringing some of the drink flowing up the straw also, just as the oil flows up the well.

Types of Oil

When oil first reaches the surface it is often dark and sticky and cannot be used in this form. First it must be transported from the oil field to the oil refinery where it is cleaned and processed into more usable forms. From large oil production platforms it usually makes this journey through pipelines, but from smaller production sites it can be transported in tanker ships to the onshore terminals.

The refining process starts with the crude oil being heated until it boils. The hot oil is put into a distillation column where it is separated out into different liquids and gases (Figure 3). The column is hottest at the bottom and coolest at the top. The gases flow up the column where they condense (turn back into liquid again). These separated liquids and gases then undergo more cleaning and processing before being used to make many products.

The different substances contained in crude oil are not present in equal quantities. Typically the approximate percentages of these substance which are refined from the crude oil are as follows:

Petrol or Gasoline	45%
Diesel Fuel and Heating Oil	22%
Other products	18%
Jet Fuel	8%
Liquefied Petroleum Gas (LPG)	4%
Bitumen or Tar	3%

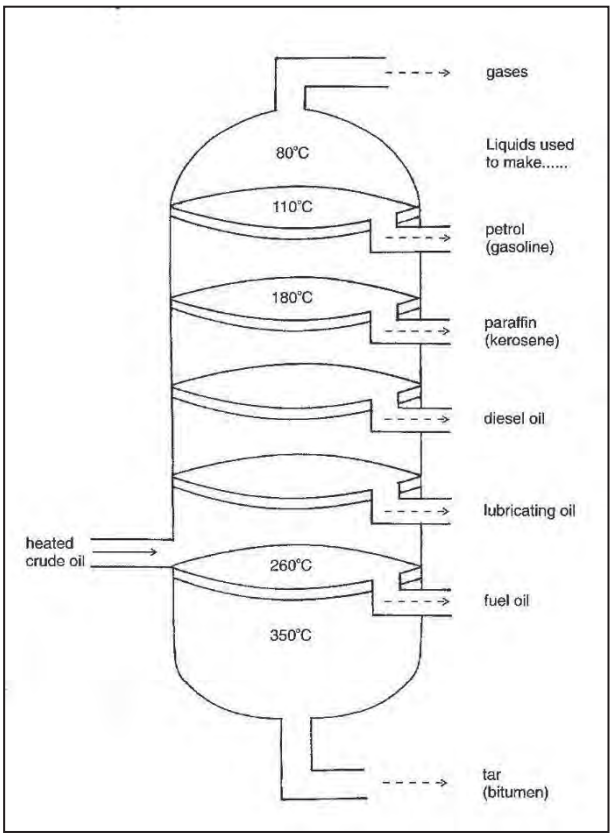

Figure 3 A stylised diagram of a distillation column, showing the order and temperatures at which the different substances present in crude oil are separated. The lighter substances are at the top, where the coolest temperatures are, and the heaviest substances are at the bottom where the temperature is much higher.

Where are the main oil producing areas?

There are many oil producing countries around the world, but ones who produce the most include Russia, Saudi Arabia, United States of America, China, Canada and the United Arab Emirates. However the countries who produce the most are not necessarily the ones who export the most oil around the world.

British Oil Fields

Britain has been recovering oil from the North Sea oil field since 1964. You may be more surprised to learn that there are some British onshore oil wells too. The best known ones include the Wytch Farm Oilfield in Dorset, which is the largest onshore oilfield in Western Europe, and Dukes Wood near Eakring in Nottinghamshire, the first British commercial oil well to go into production. Dukes Wood was an important source and supplier of oil during World War II. There is a museum on the site (pre-booking essential) and a comprehensive website.

Extension Research - Ideal for cross-curricular work linked to Geography and History:
Find out which other countries recover oil from the North Sea basin?
Which are the ten largest oil production platforms in the North Sea?
Name and locate the oil refineries which the oil is brought to for cleaning and processing?
Research the history of Dukes Wood Oil Field and its roll during the Second World War.

Uses of Oil

After crude oil has been refined and separated into its different substances (Figure 3), it can be processed further by chemical companies to produce a wide range of synthetic (not natural) materials. These processed, rather than naturally occurring substances, are then used to make thousands of innovative, useful and fun products; far too many to mention but some are listed in the following table:

Agriculture	Clothes &Textiles	Office Equipment	Sport	Medical Supplies	Kitchen & Household
Irrigation pipes Pesticides Herbicides Fertilisers Polytunnels Feeders Animal tags	Trainers Nylon zips Flip flops Rain coats Tights Man-made fibres Elastic	Ball-point pens Computers Calculators Erasers Rulers Ink Copiers	Tents Footballs Golf balls Backpacks Life Jackets Skis Gym mats Wet suits	Ointments Anaesthetic Hearing aid Syringes Spectacles Artificial limbs Heart valves	Food trays Detergents Sponges Ice trays Candles Flasks Carrier bags Clingfilm
Cars & Motorbikes	**Hobbies**	**Babies & Children**	**Beauty & Hygiene**	**Furnishing**	**Building & Home**
Antifreeze Tyres Motor oil Traffic cones Brake fluid Carpets Seats Crash Helmets	Cameras Photographs Oil paints Guitar strings Model cars Yarn CDs Videos Film	Baby Oil Bottles Bibs Disposable nappies Acrylic toys Dummies Dolls	Lipstick Perfume Hair colour Shampoo Shaving foam Mouthwash Wigs Suntan Oil	Carpet Venetian blinds Shower door Vinyl wallpaper Upholstery Cushion filling	Paints Hosepipes Roof felt Toilet seats Glue Wiring insulation Spray paint Floor wax

Useful information: Consider taking your pupils to Dukes Wood Museum and Nature Reserve. The museum also has a clear and very informative website through which you can book visits. See www.dukeswoodoilmuseum.co.uk

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