PRIMARY EARTH SCIENCE TEACHING

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FOSSIL FUELS

Coal: Formation, Uses and Distribution

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Introduction

Over the next two issues we will take another look at fossil fuels. The term fossil fuel applies to coal, oil and gas because they contain energy trapped by living organisms millions of years ago and whose remains have been converted to combustible fuels over those millions of years. These burnable properties make it a very useful and valuable resource. Its geographical distribution will also be explored after first looking at its formation, methods of extraction and some of its uses. As well as its connection to science this issue supports the geography curriculum relating to the recent inclusion of the distribution of the Earth's resources.

What is Coal?

Coal was formed millions of years ago in swamps all over the Earth. During the Carboniferous period (359 – 299 million years ago (Ma)) coal was formed in a wide area of dense vegetation in low latitudes adjacent to the equator, where Britain was located at the time. Millions of years later, within the Cretaceous period (145 – 65 Ma) when the world's climate was quite hot and plant growth was vigorous, there were formations of coal fields as far north as the Arctic Circle and as far south as Antarctica.

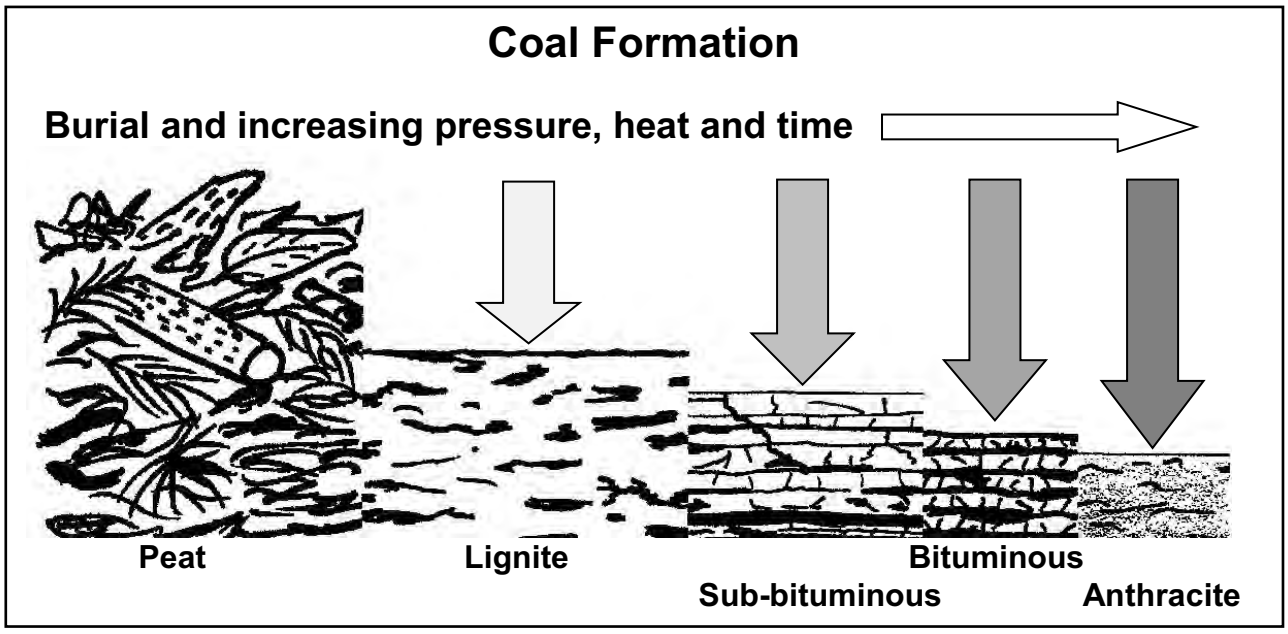
The coal was formed from plants and trees dying and falling into swamps where they were covered by muds almost instantly. This burial reduced the amount of oxygen affecting the rate of decay of the plant (anaerobic conditions). These buried plants initially formed peat. The peat was broken down by bacteria within the peat leaving plant tissue and mainly carbon behind. Pressure and heat on the peat, over time, converted it into brown coal or lignite which is a soft coal, coloured from black to shades of brown. Continued pressure and temperature over millions of years changed the formation again, this time into sub-bituminous coal. The process continued, gradually changing the formation to harder bituminous coal. This is the main type of coal for general use. A further formation sometimes occurs, again from pressure and temperature, transforming the harder coal into anthracite, a very hard coal. So coal is a sedimentary rock because it was formed from sediments. Anthracite has been changed from a sedimentary rock by pressure and temperature to a harder form so is classed as a metamorphic rock. (See page 2 for diagram about grades of coal with pressure and time.)

Types of Coal

Lignite and sub-bituminous coals are softer and friable (crumbles easily) with a dull appearance. They are low grade coals with high moisture levels and a low carbon content so have a low energy content. Larger quantities of these types of coal than the harder coals are needed to produce the same amount of heat.

Bituminous coal is harder and has a black vitreous (glassy) lustre. Bituminous coals contain more carbon and therefore produce more energy than the lower grades of coal.

Anthracite coal has a much higher carbon content and lower levels of moisture making it the best coal for producing energy.



The Three Basic Methods of Coal Extraction

1. Opencast Mining - This method involves digging out the soil and rock above the coal seams, then extracting the peat or coal from the exposed area. This method is cheaper to operate but it does cause great disruption to the surrounding areas. It takes a number of years for the land to recover, so the wild life is affected considerably.

2. Bell Pits - This ancient method involved digging a short shaft through the soil and rocks above the coal beds. When the shaft reached the coal seam, the miner would dig out an area around the base of the shaft forming a bell shaped cavity underground. This method has been replaced by the opencast method.

3. Deep Mining - Large, deep shafts need to be sunk through the ground and be large enough to allow machinery and men to be lowered down to the working depth. At the bottom of the shaft corridors are then constructed along the coal seams. These corridors need to be reinforced to prevent the corridors collapsing due to the very high pressures exerted on the roof and walls. This method of mining the coal is both expensive to operate and dangerous to run. The pressure on the shafts and corridors is enormous and, in addition, gas can be given off from the minerals underground. This gas, known as damp gas or coal gas, is explosive and can be set off by any spark. To avoid a disaster no one entering the mine is allowed to take any metal or matches with them. The deepest coal mine is in the Czech Republic and is 1550m deep.

The position of the coal beds determine the method of extraction.

Peat beds, the forerunner of coal, are usually near to or on the surface and can therefore be more easily extracted by the open cast method. Some shallow lignite beds can be extracted using this method and some bituminous coal seams are near enough to the surface to be economically extracted by open cast.

For the deeper beds of coal it is necessary to sink deep mines, a practice operated in the United Kingdom from the mid-1700s and still in operation today, but on a much smaller scale. Very few deep mines remain active in the United Kingdom. The modern deep mines are operated mechanically with very few miners working underground.

Uses of coal

There is evidence that coal has been used by humans since the Bronze Age when it was used to heat the metals to enable them to be shaped. Since then coal has been put to numerous uses. In the recent past coal has been used for burning in open fires to warm houses but the large number of these fires in the large towns and cities resulted in a dense smoky mist called a smog. The smog caused breathing problems for a large number of people so was very unhealthy. To reduce this smog the house-holders turned to cleaner fuels, reducing the amount of coal used for this purpose. Most houses are now fitted with gas or electric heating instead of the open fire.

However industry continued to burn large quantities of coal but they increased the efficiency in the way they used it.

In the past coal was used to power steam engines, both static and mobile. The static engines were used in factories to power machinery for weaving, spinning and to drive heavy industrial machines like steam hammers on forges. These gigantic machines are no longer in use, they have been succeeded by electric driven machines. The railways replaced steam trains with diesel or electric powered engines.

The biggest use of coal now is for the generation of electricity. The way coal is used for this has improved considerably over the years. The old method was to use lumps of coal in a furnace to boil water in pipes which produces steam under pressure, which then turns the blades of the turbines to generate the electricity. Whilst the basic method remains the same, the present method has stopped using lumps of coal. Instead coal is crushed into a powder and burnt in a combustion chamber under pressure which increases the efficiency of the coal by about 90%. This reduces the amount of coal used and the amount of carbon dioxide being released into the atmosphere. It is, however, still one of the major sources of carbon dioxide (CO_2) being released into the atmosphere.

Coal By-Products

Quite apart from being a useful combustible solid fuel coal can also be transformed into another valuable solid fuel – coke.

To obtain the various chemicals bituminous coal needs to be baked in an air tight furnace to 1000^0C which fuses carbon and ash together. Coke is a major product of coal and is used as a fuel in smelting iron ore in blast furnaces to produce pig iron which is then treated further to make steel. Coke is used instead of coal because most of the other chemicals have been removed by the process.

When making coke some valuable by-products are formed as coal contains a considerable amount of chemicals which can be extracted. The main chemicals are as follows:

1. Carbon can be used in water filters, air purifiers and kidney dialysis machines. Carbon fibre is a lightweight reinforcing material used in construction, e.g. tennis rackets, mountain bikes and some car bodies.
2. Hydrogen is mixed with carbon monoxide (CO) to make syngas which is converted into liquid fuel (synthetic petrol or diesel).
3. Sulphur is added to paint (for colouring), anti-freeze and insecticides. It is also used to produce the chemical sulphuric acid which is used in car batteries.
4. Oxygen is collected and stored in tanks for use in industrial welding and hospitals.
5. Nitrogen – Ammonia and urea are formed from the carbonisation process and are used in fertilizers, to aid better growth and production of plants.

The use of coal produces one of the highest quantities of CO_2, however it provide us with a vast amount of essential products. Without it we would not have the steel for construction or fertilizers for the crops or a chemical industry producing a wide variety of chemicals for medicine and everyday use e.g. rubber, cement, plastics, food preservatives and perfumes.

The Distribution of Coal

The reserves of coal are the most widespread of the three fossil fuels. Coal exists on all of the Earth's continents, including Antarctica, and is mined on every continent except Antarctica. Although coal is mined in many countries the size of those countries' coal reserves varies considerably. The countries with the largest coal reserves are United States of America, Russia, China, Australia and India in that order. However, China is the country currently producing and consuming the most coal. Despite Britain being a much smaller country than those mentioned above its coal reserves were plentiful and relatively easy to access, especially initially and when exposed at cliff sites and other outcrops.

There is evidence for the use of coal in Britain dating back as far back as the Bronze Age, 2000-3000 BC. The Romans mined coal on a larger scale but it was during the Industrial Revolution that Britain's coal reserves were mined. At this time coal was considered to be Britain's primary raw material although iron ore was abundant too. Britain had a distinct advantage over its European neighbours because its mines were close to the sea so coal could be easily transported by ship. The vast network of inland rivers and the development of the canal system could also provide relatively easy and cheap transport to major ports and industrial areas.

Research Activity

England had a number of coal fields but these coal fields are now mainly 'worked out'. Some areas are currently subjected to open cast mining as coal seams are discovered or have become economically viable. The coal industry in the United Kingdom is greatly reduced from its hey-day of the 19/20th centuries.

1. Research the locations of the main coal mining areas of Britain during the Industrial Revolution (19th Century).
2. Research how the coal mining industry changed during the 20th Century.
3. Plot the main coal mining areas onto an outline map of the United Kingdom and compare these areas with the main industrial sites and ports.
4. Choose one of the coal mining areas and research its history.
5. Try to find out where most of that coal mining area's coal was transported to and what industries it was used in.

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