Environmental Studies
FACT SHEET
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Extraction of Petroleum

Introduction

Petroleum is found in the microscopic pores of sedimentary rocks such as sandstone and limestone. Not all of the pores in a rock will contain petroleum - some will be filled with water or brine that is saturated with minerals. Seismic surveys are used to try to predict where oilfields may be but the only way of making certain is by drilling.

Not all of the oilfields that are discovered are exploited - the oil may be far too deep or of insufficient volume or the oilfield may be so remote that transport costs would be high. Often, it is the nature of the oil that is the problem - it may have too great a sulphur content or too low or high a viscosity. Such fields may, of course, be worth exploiting in the future if demand begins to exceed supply.

UK Petroleum and Gas

- Reserves of gas and oil were discovered in the North Sea in the 1960s. Gas was recovered in 1965 and the first oil was brought ashore in 1975.
- The first oilfields to be developed were in shallow water (50-100m). As oil prices rose in the 1970s and technology improved, oil was extracted from deeper water (200m).
- Since 1964, 6000 wells have been sunk in the North Sea.

Fig. 1a North Sea sectors.

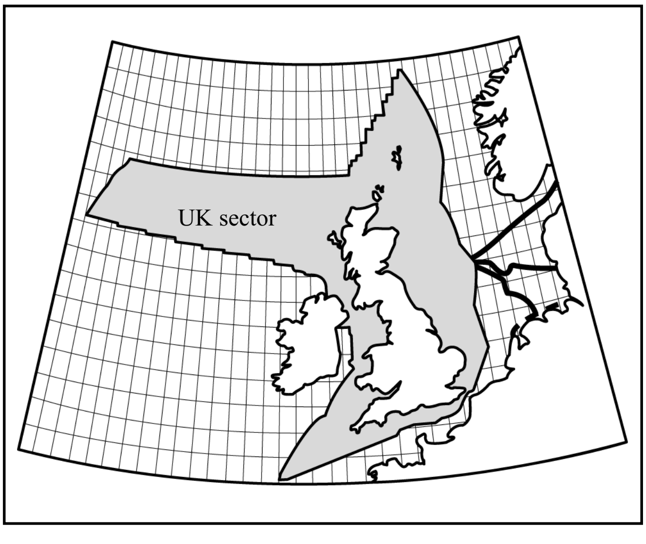


Fig. 1b North Sea oil production installations.

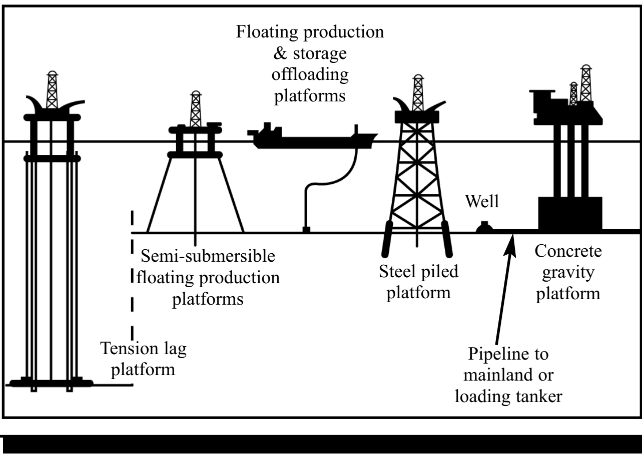
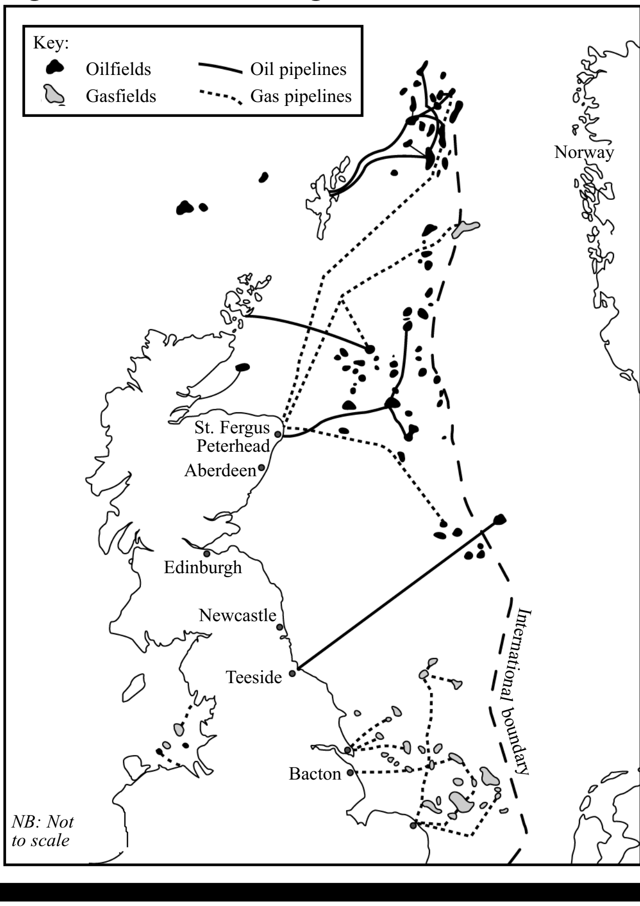


Table 2 Major world oil reserves.

Middle East (Saudi Arabia, Iraq, Kuwait, Abu Dhabi, Iran)	63.0%
North America	9.0%
South America	8.0%
Soviet Union	6.0%
United Kingdom	0.4%

- 90 countries have significant oil and gas fields.
- The UK consumes 4% of the world's oil and 3.2% of its gas (the US is responsible for 25% of world oil consumption).
- The UK holds 0.4% of oil and 0.5% of gas reserves *(Fig. 2)*.

Fig. 2 UK offshore oil and gas fields.

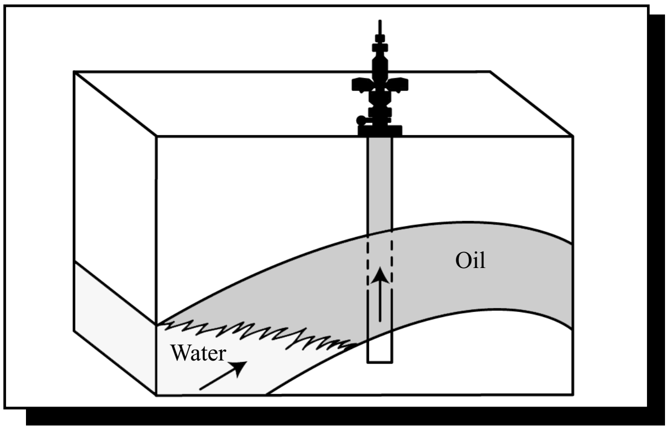


Primary Recovery

All fluid petroleum is trapped underground at high pressure. **Primary Recovery** refers to the process in which the petroleum in the reservoir trap is forced to the surface by the natural pressure contained in the trap. This pressure may result from several forces:

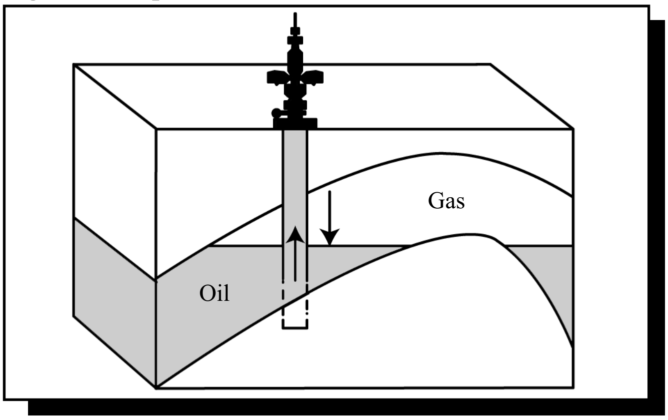
1. Water beneath the petroleum may be pressing upwards. When the oil is penetrated the water layer expands and pushes the oil upwards and replaces it in the rock pores. This is the most effective technique and is known as a water drive system *(Fig. 3)*.

Fig. 3 Water drive



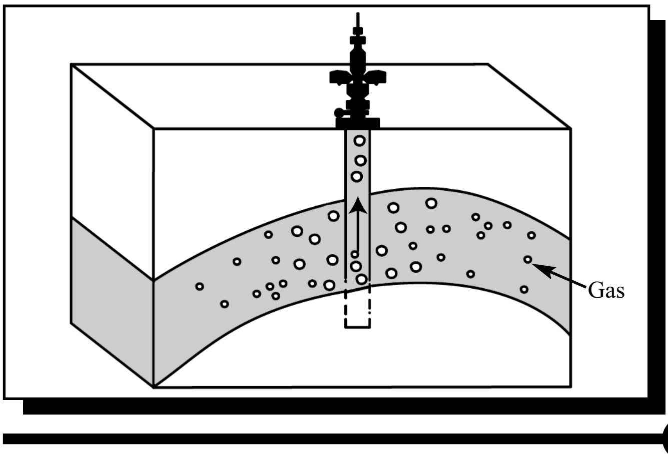
2. If the drill penetrates into a layer of oil which has a gas cap above it, the gas layer will expand rapidly causing a downward pressure on the oil forcing it to move up through the well (gas cap drive *Fig. 4*).

Fig. 4 Gas cap drive



3. Gas dissolved in the oil may be released as bubbles when the trap is pierced. As the oil moves up, the gas in the oil expands and the growing bubbles push the oil to the surface (solution gas drive *Fig. 5*).

Fig. 5 Solution gas drive



In most reservoir traps, these pressures are sufficient to initially force the petroleum to the surface. At some point in time, this pressure will fall. Petroleum production falls because:

- *There is less force driving the oil towards the well.*
- *The gas that moves into the emptied pore spaces reduces the permeability of the rock, making it more difficult for oil to flow through.*
- *The fall in pressure and the loss of dissolved gas increases the surface tension and viscosity of the oil.*

For this reason, Primary Recovery techniques usually account for less than 5 - 30% of the total volume of petroleum recovered. The remaining petroleum is recovered by secondary and tertiary recovery techniques.

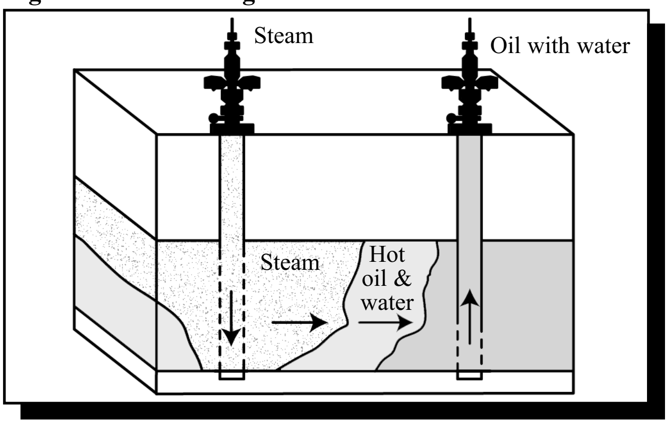
Secondary Recovery

Secondary Recovery involves trying to maintain reservoir pressure. One technique is to inject natural gas into the reservoir above the oil, forcing the oil downwards, and then injecting water below the oil so forcing it upwards. Sometimes the gas that is used is that which has just been released during Primary Recovery. The disadvantage of using the released gas is that this gas is a marketable product in its own right. However, this is a good method to use if transporting the gas would be costly and, in any case, the re-injected gas can always be collected again if necessary. Alternative secondary techniques involve injecting carbon dioxide or nitrogen into the oil. This makes the oil more fluid and the gas pushes the oil upwards.

Tertiary Recovery

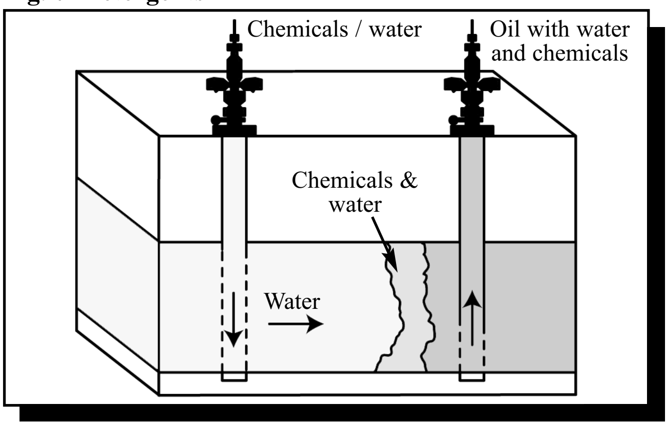
This is the most expensive approach and involves injecting steam, detergents, solvents, bacteria or bacterial nutrient solutions into the remaining oil. When high-pressure steam is injected it heats the oil, decreasing its density and viscosity and increasing its flow rate *(Fig. 6)*. Sometimes, some of the oil in the reservoir rock is deliberately set on fire. This is used to increase the flow rate of the oil ahead of the combustion front.

Fig. 6 Steam flooding



Detergents which can be injected reduce the viscosity of the oil and act as surfactants reducing the ability of the oil to stick to the rock surface and thus making it easier for it to be flushed up to the surface *(Fig. 7)*.

Fig. 7 Detergents



A third Tertiary Recovery technique involves injecting bacteria into the oilfield:

- Some bacteria produce polysaccharides which reduce the permeability of the water-filled pores of the reservoir rock and this effectively forces injected water into the oil-filled pores, pushing the oil out.

- Some species produce CO_2 gas which helps to increase pressure within the rock pores, forcing out the oil.

- Some species produce surfactants or other substances that reduce the viscosity of the oil.

Almost all oilfields contain naturally occurring bacteria, some of which use sulphur in the oil as an energy source. This process releases hydrogen sulphide. This is the gas that smells like rotten eggs and, of course, any sulphide compounds in the oil present a problem because when the oil is burned SO_2 will be released.

A new technique developed in the US involves adding nutrients to the oilfield that tips the balance against the sulphide-producing bacteria in favour of beneficial species. These useful species also produce large amounts of surfactants, solvents and gases that help mobilise residual oil trapped within the reservoir.

A huge amount of investment goes towards improving extraction techniques. In the 1980s recovery factors (the proportion of petroleum that can be extracted) averaged 30%. In 2000, the industry standard was 45% and this improvement is largely due to:
- improved design and materials used in drillbits.
- the development of horizontal drilling technology which has increased the ability to exploit thin but wide reserves.

Table 1 Petroleum recovery in US oilfields.

Method	% of petroleum extracted
Primary Recovery	37
Secondary Recovery	51
Tertiary Recovery	12

The US produces 5.8 million barrels of oil per day.

Typical Exam Questions
You must be able to:
1. Outline the principles of primary, secondary and tertiary recovery.

2. Explain why some oilfields are deliberately not exploited

3. Describe the environmental consequences of petroleum extraction (this will be covered in more detail in a future factsheet

Environmental consequences
- The recovered oil is a mixture of oil, gas and water. The oil is separated out and the waste water is pumped into the sea. This water contains impurities such as hydrocarbons and sulphides.

- Excess gas is released in burning flares, releasing CO_2 and particulates.

- Seismic surveying is used to try to locate oilfields. This involves producing minor explosions (250 decibels) with air guns and by measuring the reflected sound waves geologists can deduce the underlying geology. The sound explosions disturb cetaceans (whales and dolphins), displace fish stocks and can damage the swim bladders of fish.

- During drilling, lubricants (drilling muds) are pumped down to keep the drillbit cool and to regulate the flow of oil and gas. Lubricants contain heavy metals such as mercury and lead, as well as detergents and biocides.

- Drill cuttings are dumped on the seabed and can suffocate seabed fauna.

- The installation of the oilrig and pipeline involves dredging, filling and anchoring, all of which can affect wildlife.

- Oil that leaks into the sea, either during extraction or as a result of disasters such as the Sea Empress, has lethal and sub-lethal effects that include:
  - smothering
  - reduced insulation of fur and feathers
  - inability to fly
  - damage by vapours to liver and central nervous system
  - food chain effects
  - damage to embryos

Sources of Information
Institute of Petroleum www.petroleum.co.uk
Corporate Watch www.corporatewatch.org - You can download a 20 page action guide for anti-oil campaigners that contains a lot of interesting information on the North Sea oilfields and distribution network.

Acknowledgements
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