7

SATIS 8-14

Box 3

First published in 1992 by
Association for Science Education
College Lane
Hatfield
Herts AL10 9AA

Compiled and edited by
John Stringer

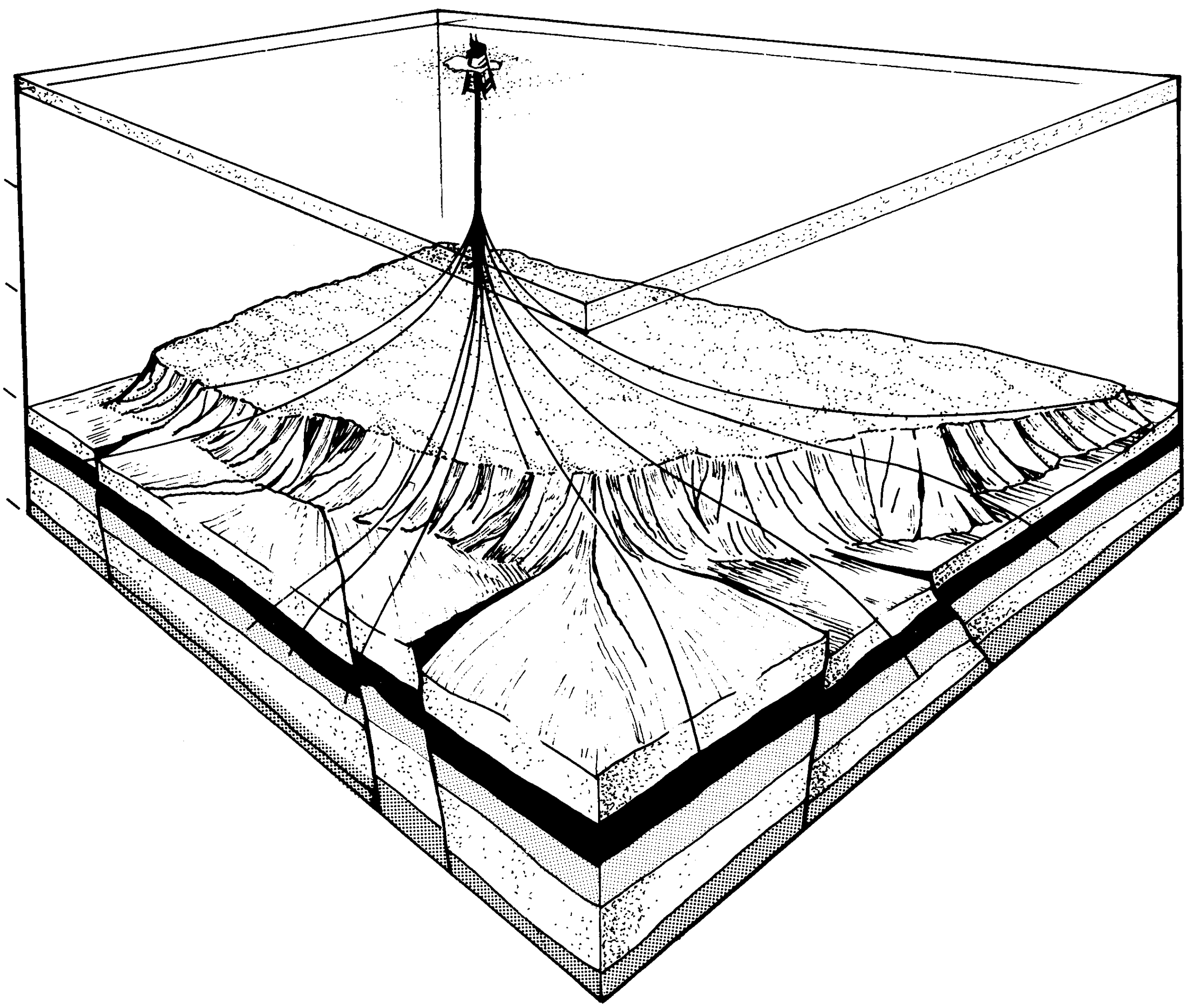
Designed, illustrated and produced by
Fieldwork Limited
2 Lower Brook Mews
Ipswich
Suffolk IP4 1RA

A catalogue record for this box is available
from the British Library

Printed in England by
The Lavenham Press
Water Street
Lavenham
Suffolk

Box 3 ISBN 0 86357 153 0

Book 7



SATIS 8-14

Science and Technology in Society 8 – 14 Team

Project Director	John Stringer
Team Members	Anabel Curry Polly Fenn Gerald Haigh
	Rob Johnsey John Slade Mary Whitehouse
Resources	Grant Burleigh
Secretary	Anne Tole

Contents

Association for Science Education

Oil from beneath the sea

This series of five units deals with aspects of the science and technology of oil extraction. There is particular reference to that source of UK oil which is several kilometres beneath the North Sea bed. The series starts with a consideration of the social consequences of living in a 'town in the North Sea'.

Schools may welcome the possibility of inviting a Petroleum Engineer to visit; please contact:

Eileen Barrett – Recruiting Consultant
Department of Mineral Resources Engineering
Royal School of Mines
Prince Consort Road
London SW7 2BP

The set of units could be used as a framework for inter-departmental co-operation with Y7 or Y8 pupils. The following departments, in particular, would find relevant material:

Geography

History

Maths

Personal & Social Education

Science

Technology

The unit writing was supported by the Society of Petroleum Engineers (SPE).

Video material for use with this unit has been supplied by Shell UK Limited and the Shell Film and Video Unit. The video is divided into four units; the unit number is shown throughout at the top of the screen.

Additional material has been supplied by Phillips Petroleum and the Occidental North Sea Group.

See also the other energy-based units in SATIS 8–14; especially those on alternative energy sources.

A town in the North Sea

Contents

Part A
Why live on a platform? Pupils prepare an itinerary for travel to the platform, and discover time required.

Part B
What is needed for a town in the North Sea? Pupils study what is needed to maintain life on the platform.

Part C
Different parts of a North Sea platform. Pupils identify some of the main components of a platform. They construct a simple model. The unit ends with how electricity is generated for use on the platform.

By using the unit pupils will

- explore different ways of **displaying data**.
- consider the necessities of life.
- consider aspects of the quality of life.
- investigate the **distillation** of salt water.

Curriculum focus

Pupils should learn how to separate and purify the components of mixtures.

Pupils should investigate changes of state.

Pupils should be made aware of the range of sources of raw materials.

Pupils should investigate ... the properties of water.

Pupils should discuss the use of fuel/oxygen systems as concentrated sources of energy in ... engines, heating systems and other devices.

Managing the unit

A variety of strategies is suggested, including individual, small group and whole class work.

Communication is encouraged by discussion, poster work, preparation of written charts, role play and by focused study of short excerpts from a videotape.

Teacher notes

Part A

Why live on a platform?

The first pupil activity draws attention to the time and difficulty of getting to a North Sea oil platform. Pupils will need access to appropriate rail and air time-tables. If the suggestion is made that the journey should start by taxi, then one pupil might contact a taxi company to obtain information for the entire class.

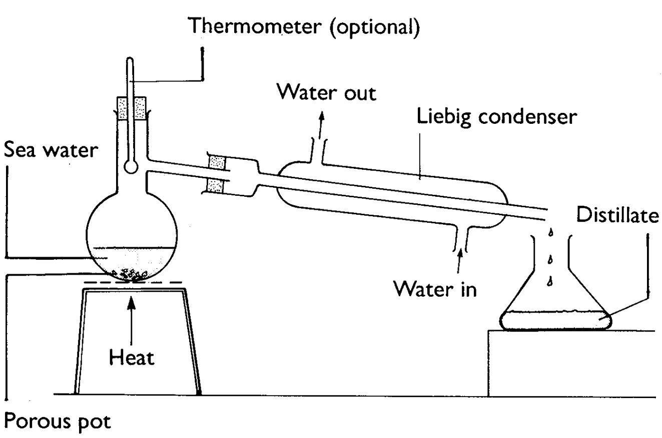
As an introduction, the class watch the video excerpt UNIT 3, 2 mins 20 secs on the video. (The number 3 remains on-screen throughout). This shows the platform manager saying good-bye to his family before leaving for the long and arduous journey to the platform.

Travel times from most parts of the UK are so great as to make it obvious that daily travel to and from work would be impossible. This is why the platform has to become a temporary home for those who work there.

Part B

What is needed for a town in the North Sea?

This part has four activities. It culminates in a whole class discussion about the quality of life on a North Sea platform. The discussion would be better informed if a petroleum engineer were present. An address is given, in the introduction to these units, of the Recruiting Consultant to the SPE who can put you in touch with one.



Activity 1

Pupils produce lists of 10 items which they consider important for life on a platform, together with an indication of transport implications. The work develops in four stages. At first, pupils work individually. They then discuss their ideas in small groups to produce a poster of essential items. Individuals review their original lists. They indicate how the essential items would be transported to the platform.

Activity 2

Pupils distil salt water, using the simple 'boiling tube still' apparatus described in science text books.

⚠ Eye protection must be worn.

If 'sea water' has to be simulated, the following recipe is realistic:

11g sodium chloride and 1.3g magnesium sulphate in 1 litre of water.

If demonstration apparatus is available, it would be helpful to demonstrate rather more sophisticated distillation techniques, for example using a Liebig condenser. If distilled water for use in the laboratory is prepared by means of a commercial still, then that still should be studied and its operation explained. Extension into de-ionisation could be considered but only if it would not lead to confusion in pupils' minds.

To distinguish the distilled water from the sea water, two tests are proposed. The first compares the boiling points of the different water samples. The second investigates the concentration of chloride. It will probably be necessary to augment the pupils' own distilled water with more from a demonstration still. As a reagent for the second test, a dilute solution of silver nitrate is excellent but too expensive for more than a single demonstration; if the 'sea water' has a sufficiently high concentration of chloride ions, then a cold, concentrated solution of lead nitrate would give a white precipitate of lead chloride with the 'sea water'.

⚠ Poison! Wash hands after this activity.

Activity 3
Pupils work in pairs, one taking the role of the catering manager, the other being the chief cook. They decide on a breakfast menu and work out an order for the food they will need. They decide appropriate meal times for the two shifts. Finally, they plan emergency provisions and storage. (Allow a homework period for preparation for this activity.)

Activity 4
The four stages of this activity require careful attention to the changes in pupil grouping. Stage 1 is a small group discussion of some of the issues which will be highlighted when they study the video. In stage 2, the different members of each group agree to concentrate on a different aspect of life on a North Sea platform, when they watch the video. Stage 3 is designed to facilitate the sharing of the information gained as a result of the video study. The final stage is a whole class discussion about details of life on a platform, and its quality.

The focus of the activity is a study of the following snippets of videotape, all numbered UNIT 4 throughout.

- 'The installation supervisor' (2 mins)
- 'The tool pusher' (1 min)
- 'A town at sea' (2 mins)
- 'The safety ship' (1 min)
- 'Accommodation on the platform' (2 mins)
- 'Emergency drill' (2 mins)
- 'Medical and leisure facilities' (40 secs)

Those pupils who study different jobs should identify types of work, and some of the unusual names used in the oil industry. You may find it helpful at this stage to look at the first part of Unit 5, which returns to the question of jobs and has a fact sheet with descriptions.

Part C
Different parts of a North Sea platform

There are three straightforward things to do.

1 A simplified diagram of a North Sea platform is provided, for labelling of major components.

2 A model of a platform can be made.

3 Finally, there is a fact sheet about power generation for use on the platform, with questions.

Answers

1 Gas is used as the fuel, the crude, unrefined oil from the well being unsuitable.

2 The products of combustion will be mainly carbon dioxide and water vapour.

3 Hot gases possess more energy than cold, and so exert a greater pressure on the turbine.

4 The fuel has chemical energy (a form of potential energy). When the fuel burns, some of this energy is converted to the kinetic energy of the gas molecules. Some of this is converted into electrical energy in the power turbine.

Why live on a platform?

Copy out this timetable, and then read the notes below to help you fill it in.

From	(time)	to	(time)	journey time	transport
Home				hours	
				hours	
				hours	
		Aberdeen		hours	
Aberdeen		Platform		2 hours	Helicopter

Do you know anyone who works on an oil platform in the North Sea? Imagine that someone who lives near you has to travel to an oil platform to work. You are going to find out how long it would take your neighbour to travel from home to work.

1 Work out the times backwards, starting from the oil platform, but note there are helicopter flights from Aberdeen to the oil platform each day at 06.30 and 12.30; each flight takes about two hours for the 150-mile journey and your neighbour must check in one hour before take-off.

a What time must your neighbour arrive in Aberdeen to get to the platform before 09.00?

b What time must your neighbour arrive in Aberdeen to get to the platform before 15.00 ?

2 You must decide whether your neighbour will travel to Aberdeen by train or air.

Which InterCity station, or airport, will your neighbour need to use? (You may need to use an atlas or travel timetables.)

3 You will need to look at a travel timetable to find out the times of trains or planes to Aberdeen. Look back to your answers to 1a and 1b, and decide which are the best times.

When should your neighbour catch the train or plane? What time does it arrive in Aberdeen?

Now you can fill in the last two lines of your timetable.

4 How will your neighbour travel to the station or airport? How long will it take? So, when should your neighbour leave home?

Now fill in the rest of your timetable. (Don't worry if there are more lines than you need; just leave them blank.)

How long does the whole journey take from home to the platform?

What if there were any unexpected delays? Can you think of three possible causes of delay?

You can see that the workers on the platform have to stay for several days at a time because the journeys are so long and difficult.

What is needed for a town in the North Sea?

You will need:

- eye protection
- a Bunsen burner
- a boiling tube 'still'
- a stand for your 'still'
- a receiving tube
- a beaker of cold water.

Activity 1

You and your group are going to decide what you would need if you had to live and work on a platform in the North Sea.

1 On your own, think of ten things which you would need.

2 Join your group to discuss each of your lists. Make a group list of those items which were on at least half the individual lists. Make a group poster of 'North Sea necessities' and display it with the posters of other groups.

3 On your own again, rewrite your own list using any new ideas from all the group posters, but stick to a maximum of ten items.

4 When you have finished your list of ten essential items, write beside each one where it will come from – whether it will already be at the platform or whether it must be taken there by ship or helicopter.

Activity 2

There is plenty of water around a North Sea platform but do you think you should drink it? This next activity shows you and your group how to purify some sea water.

⚠ Put on the eye protection and set up the rest as in the diagram.

- You will need a small Bunsen flame (just over 2 cm), with the air hole half closed, so that the sea water can be heated gently but without getting soot all over the bottom of the test-tube.
- When the sea water is boiling, lower the flame still further in order to keep the water boiling gently.
- Collect several drops of distilled water and then turn off the Bunsen burner completely.

Carry out these two tests on samples of sea water and distilled water.

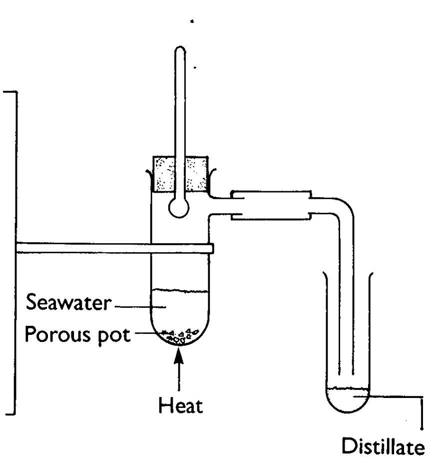
1 Heat a sample of sea water until it boils and note the boiling temperature.

Now heat a sample of the distilled water and note the temperature at which it boils.

2 Pour a little sea water into a test-tube (to a depth of about 2 cm). Add a similar volume of the 'salt testing solution'. Note what happens.

Do the same test with a little of the distilled water.

Some hot countries have a serious shortage of fresh water and have to use the Sun's heat to distil sea water. What do you think North Sea platforms use to heat sea water in their own distillation plants?



What is needed for a town in the North Sea?

MENU
Friday
Lunch

Lentil or Mulligatawny soup
Poached hake mornay

main course choice of:
Sage stuffed leg of roast lamb
Curried beef with rice
Grilled liver and bacon

vegetarian
Stilton and asparagus quiche
cold cuts

Chipped/boiled/jacket potatoes
marrowfat peas/Vichy carrots

Dinner

Pate maison
Soup of the day

Rainbow trout Cleopatra

main course choice of:
Breaded pork cutlet
Beef Stroganoff
Greek moussaka

vegetarian
Mixed bean curry

Hash brown/chipped potatoes
Savoury cabbage/macedoine of vegetables

Supper

Florida cocktail
Soup of the day

Fish cakes with tartare sauce

main course choice of:
Grilled steak with sauce chasseur
Chicken curry with rice
Scotch eggs

vegetarian
Pasta Niçoise

Chipped/Lyonnaise potatoes
Broccoli/braised leeks

Activity 3

What about meals on the platform? Work in pairs, with one of you taking the part of the catering manager, and the other being the chief cook. Work together to plan some meals and prepare the necessary orders for food deliveries.

Decide who is to play the part of the catering manager and who is to be the chief cook. (You may both find it helpful to spend a short time looking at an actual menu for a platform called 'Brae A'.)

1 You are on a large platform, with 100 people to feed. The supply boat is usually able to call every three days. Decide what you will provide for breakfast for one of these 3-day periods. Work out what food you must order.

2 There are two working shifts, from 06.00–18.00 and from 18.00–06.00 next morning. Decide at what times you will serve the three main meals for each shift worker.

3 The supply boat is not always able to sail to the platform in very stormy seas. What types of food would you keep for such emergencies; how would you store these emergency rations?

Activity 4

Use this acivity to find out what it is like to live and work on a North Sea platform.

1 In a group of four, discuss the following questions and note down your decisions.

What different types of waste do we get rid of from our homes? How might these types of waste be disposed of on a North Sea platform?

Gas and electricity are the main sources of power on a platform. How do you think the electricity is generated?

Safety is extremely important on North Sea platforms. Why? List the safety issues and precautions that must be considered on a North Sea oil platform.

2 You will be able to study short sections of a video about life on a platform. Each member of your group will concentrate on a different issue. The four issues are living conditions, safety procedures, statistics and jobs.

In your group decide who will study living conditions.

After watching the video, you should be able to answer questions like:

- *where do people sleep?*
- *what is the food like?*
- *what do people do in their spare time?*

What is needed for a town in the North Sea?

- *what happens if they are ill, or if they have tooth-ache?*
- *how do people get from place to place on the platform?*

Decide who will study safety procedures.

That person should look and listen for all references to safety and try to write down what is said or done about it.

Decide who will study statistics.

That person should listen carefully to the commentary and, whenever numbers are quoted, write down the numbers and what they refer to.

Finally, decide who will study the different jobs.

You would expect there to be engineers, concerned directly with the extraction of the oil. You would not expect them to prepare their own meals and so there must be cooks. What jobs are shown in the video?

You are now ready to watch the seven short snippets of videotape.

3 When everyone in your class has studied the video and made notes, form a new group with the others in your class who were concentrating on the same aspect as you.

Your teacher will tell you where you and your new group will meet.

Share what you have each found out about your aspect of life on a North Sea platform and make a list of all the details you noticed.

Decide how to present your findings to the rest of the class.

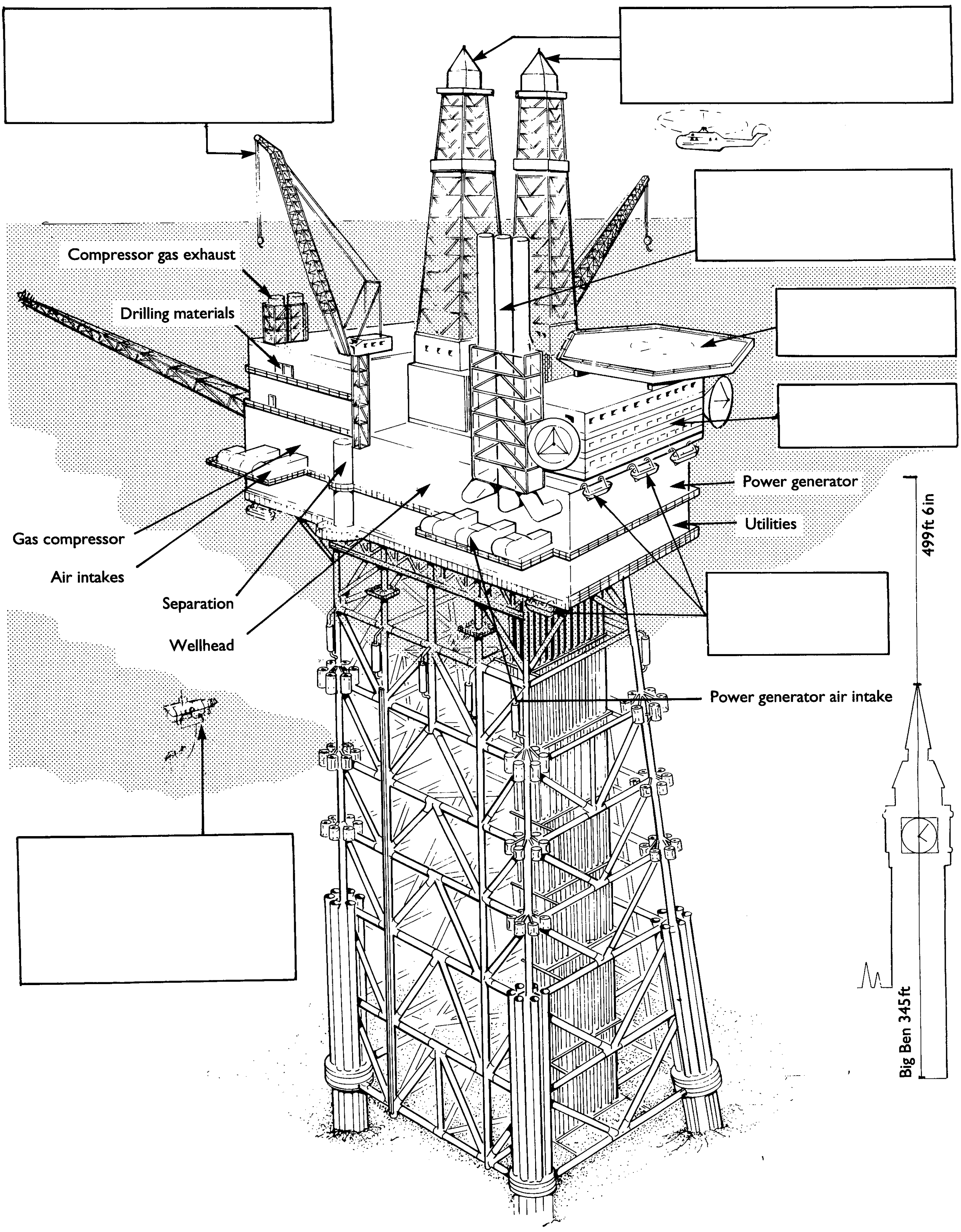
4 You are now ready to draw together all the ideas about life and work on a platform.

You have collected these ideas in:

- your own lists of essential items.
- the posters of 'North Sea necessities'.
- notes about purifying water.
- the work you did in preparing menus and ordering food.
- the latest presentations on living conditions, safety procedures, statistics and jobs.

When you have looked back at your notes on all these ideas, discuss what you think life would really be like on an oil platform out in the wild and stormy North Sea. Finally, when you have discussed all these aspects, take a vote to find out how many from your class would be prepared to work there.

Different parts of a North Sea platform



Different parts of a North Sea platform

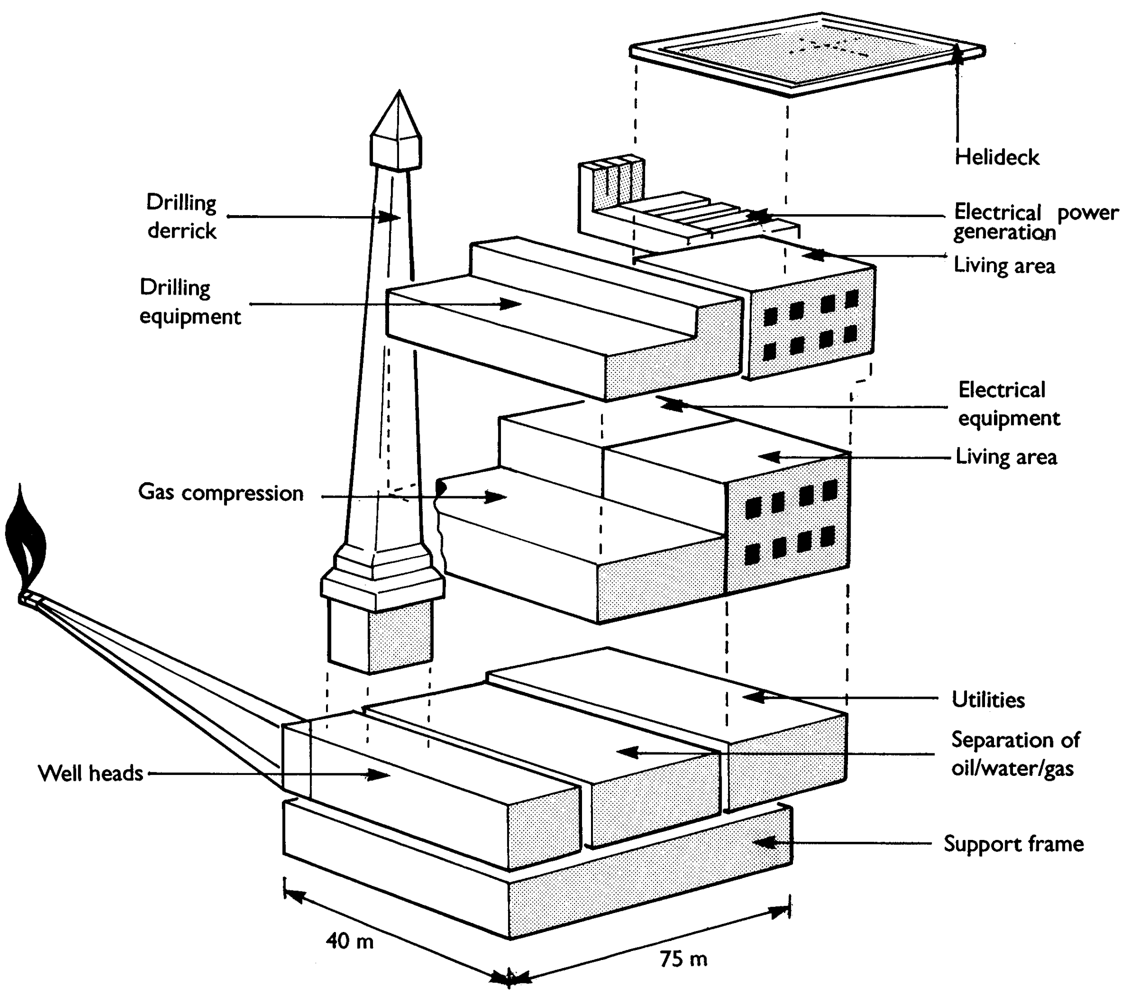
Activity 1

The diagram of a North Sea platform is incomplete. Please label the following:

- the helicopter deck
- the living quarters
- the chimney for waste gas from the generator
- cranes
- drilling rigs
- flare tower
- submarine
- lifeboats

Activity 2

Use the plan of a North Sea platform to construct a model.



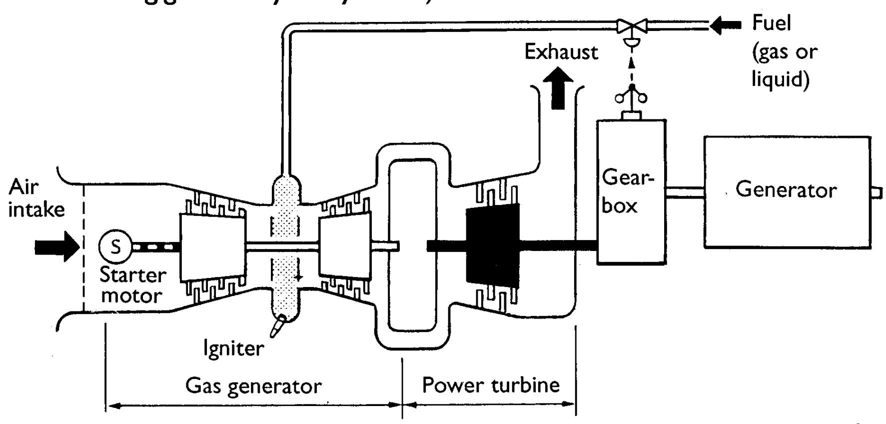
Different parts of a North Sea platform

Activity 3

Generating electricity

The power supply on a platform uses energy from gas which is found with the oil. There is usually sufficient gas from the 'separators'. In Unit 5 you will find out how gas is separated from the oil. If supplies of gas are low, then diesel fuel is used to run the engines.

Most platforms use jet engines similar to those used in aircraft, for example the Olympus engines like the ones in Concorde. The engine turns a generator in order to produce electricity for the platform. (It is rather like a gigantic bicycle dynamo.)



The starter motor sets the gas generator turbine in motion. Compressed air and gas are passed into the combustion chamber. The gases are ignited and the hot burning gases pass to the power turbine. They cause the power turbine to rotate. This transfers movement to the generator through a gear box.

Gas is very often found with oil. This gas is mainly methane, which contains carbon and hydrogen and has the chemical formula CH_4.

1 *What do you think will be the main products when the gas burns in the oxygen which is present in air?*

Complete this word equation for the burning of methane:

methane + oxygen ⟶ __________ + __________

2 *Why is it important that the gases which drive the power turbine should be hot?*

Fill in the missing words, describing the main kind of energy at each stage. Different people may not use exactly the same energy words but if it helps you to choose from a list, try to fill the blanks with one of the following four words: electrical; heat; movement; stored.

3 *When the fuel burns, the __________ energy of the fuel is changed into __________ energy in the products. This __________ energy provides __________ energy to the turbine. The dynamo generator then produces __________ energy to be used on the platform.*

Petroleum – the raw material

Contents

Part A
The changing importance of oil. Pupils consider the importance of oil in today's world and compare this with its changing importance over the past 150 years.

Part B
Some petroleum statistics. Pupils display information about oil's standard unit – the 'barrel', the dramatic growth in production of oil, its use today, and the economics of the petroleum industry.

By using the unit pupils will

- carry out a literature search.
- compare and contrast diagrams, bar charts, line graphs, and pie charts.
- explore economic realities of an industry.

Curriculum focus

Pupils should be made aware of ... sources of raw materials, including those derived from fossil fuels. They should relate reactions to information about manufacturing processes involved in ... the petrochemical industry.

Managing the unit

Pupils work individually or else in small groups. It would be valuable to conclude Part B with a whole class discussion of the merits of different ways of conveying a variety of types of information.

Teacher notes

Part A
The changing importance of oil

As an introduction to the topic of oil, pupils work individually to think about reasons for oil's importance in the world today.

In the second activity, pupils work in groups to trace the change in importance, from the mid-nineteenth century, of oil for paraffin lighting to oil for petrol and motor vehicle transport.

There is also an optional activity in which pupils are asked to draw a picture of the development of either house lighting or mechanised transport.

Part B
Some petroleum statistics

Each of the four tasks associated with Part B involve the presentation of information in diagramatic form.

It is suggested that pupils work in groups of eight, sub-dividing into pairs so that each pupil is involved with the actual drawing of only one of the four diagrams. To convey different kinds of information as clearly as possible different types of diagram are required. For the four tasks, the following are appropriate:

Task 1 – the size and weight of a 'barrel' of oil

Pictures may be drawn of collections of objects which would have equivalent volume and/or weight. (For example, a row of petrol cans might indicate volume, or a pyramid of bags of sugar might indicate weight.) Alternatively, pupils could draw scale diagrams to show the relative magnitude of various units, especially of volume.

Task 2 – increases in the production of oil since 1910

Bar charts may be attempted but the expansion is exponential and it will be difficult to choose an appropriate scale. A curving line graph is more satisfactory. (It can add to the understanding of the graph to include a small picture of a primitive oil lamp, an early car, and an aeroplane above the appropriate dates.)

The exercise could be extended into a study of the dangers of extrapolation from very limited data.

1 Provide at first only the following data:

   'Oil production in 1910 was less than 1 million barrels/day. By 1930, production had risen to more than 5 million barrels/day.

   In 1950, production was over 10 million barrels/day. 20 years later, in 1970, it was approaching 50 million barrels/day.'

2 Ask pupils what production might have been in 1990 and they could reasonably argue that it should have been rising towards 100 million barrels per day.

3 The more complete data would then be presented for drawing the graph and for discussion of the dangers of extrapolation.

The evidence provided shows a fall from 1980 to 1985, followed by a resumption of rising production. From the figures given, pupils could reasonably expect 1990 to be the year of maximum production. (In fact, production in 1982 exceeded 62 million barrels/day and this was in reality the year when production was greatest – an example of misleading statistics.)

Task 3 – different products from oil

Refining produces a variety of petroleum products. The petroleum industry produces information about the range of these products, often in the form of a refinery flow plan showing differences but not proportions. Because Part A of this unit dealt with changes in the major uses of oil, the information here is grouped according to usage, in order to give approximate proportions, and not according to the different refinery 'fractions'. For example, 'feedstocks' for the chemical industry come from several 'fractions', with different boiling ranges.

A pie chart will be the most appropriate diagram to show proportionality, not just relativity. Bar charts will show relativity in the different uses of oil but not the proportions. For quick reference the pie chart data are given below.

Use	**Proportion**	**Pie chart angle**
fuel for cars & other road vehicles	30%	108°
fuel for domestic & commercial heating	23%	83°
fuel for heavy industry	15%	54°
fuel for electricity generation	11%	40°
fuel for transport by air, sea & rail	9%	32°
feedstock for the chemical industry	7%	25°
lubricants, waxes, bitumen products	5%	18°

Task 4 – the costs, profits & taxes of a petroleum company

As with 3, above, pie charts have the advantage over bar charts of showing the proportion of spending on a particular aspect.

Profits are all that remain after the cost of crude oil and producer country taxes and levies have been deducted from the total sales. The profits were therefore $19 bn.

The changing importance of oil

Activity 1

If you could wave a wand and remove from the world everything that is made from oil, or that depends on oil, what do you think would be left?

As you work through these units you will begin to see how important oil is in all areas of life. In fact, it is so important that oil has been called 'black gold'! Competition between people and nations for the control of oil fields and their supply lines has been blamed for wars. A sudden increase or decrease in oil prices (or even the threat of a change) has caused panic in the money markets around the world.

- *Why do you think oil is so important? Write down as many reasons as you can think of, and keep the list for later on.*

Activity 2

Oil straight from the ground is called crude oil. Most crude oil is so thick that it is more like tar and can be used for waterproofing. Crude oil has been used as a fuel but it is difficult to get it to burn and it is very smokey. Nowadays, oil is not used in this crude form but it is first treated in an oil refinery. In a refinery, crude oil is changed and separated into different parts, called 'fractions'. The list shows some typical 'fractions' from a modern oil refinery.

- Refinery gases (like butane)
- Motor gasolines (like petrol)
- Chemical feedstocks
- Kerosene (paraffin)
- Diesel oils
- Lubricants
- Fuel oils
- Bitumens (tars)

Find out the boiling points of the 'fractions' and you will then see that they follow a pattern. What is the pattern of boiling points?

The first refinery went into operation in 1860. The main product was paraffin for lamps. Everything else was either burnt off or allowed to run into the ground.

The car industry developed at the beginning of the 20th century and after 1912 petrol overtook paraffin as the most important product of oil refineries. Since then, uses have been found for all the other 'fractions' (which had been wasted), and in this way the modern oil industry developed.

Something for you to do! This time you have a choice of subject:

Either – the development of house lighting

or – the development of mechanised transport.

Draw a picture history to show how house lighting, or mechanised transport, developed from 1850 to 1950. You will probably need to look at encyclopedias, and you may find out a great deal by asking older people about their memories.

Some petroleum statistics

There are four tasks for each group. Read what has to be done in each case and discuss what sort of diagrams you can draw to show the different kinds of information. Then decide who will tackle each task – you can draw the diagram on your own, or else as a pair. When you have all finished, look at your group's set of diagrams and then revise the list you made about why oil is so important.

Task 1 – the size and weight of a barrel of oil

The 'barrel' is a unit of measurement used only in the oil industry. It was originally the size of a container which a donkey could pull on a cart.

One barrel contains approximately 160 litres of oil. Each litre of crude oil weighs about 0.8 kilogrammes. The exact weight depends on the composition of the crude oil and this varies from place to place.

Draw diagrams to give an idea of the size and weight of a barrel. (For example, you could draw a collection of objects which have a similar weight to a barrel of crude oil, and drawings to show the size of the barrel compared to other containers. Or else you could draw scale diagrams of different units of weight and volume, compared to a barrel.)

What is the approximate weight of one litre of water? Does this vary with the source of the water?

Task 2 – increases in the production of oil since 1910

Year	Barrels per day	Year	Barrels per day
1910	900000	1970	47500000
1920	1900000	1975	52700000
1930	4100000	1980	59800000
1940	6000000	1985	53500000
1950	10800000	1990	60400000
1960	21900000		

Draw a graph of oil production since 1910.

You will probably find it easier to plot the graph in 'hundreds of thousands of barrels', that is from 9 in 1910 to 604 in 1990.

Be careful with the intervals; 10-yearly up to 1970, and then 5-yearly up to 1990.

From your graph, when do you think world production reached a maximum? What was the approximate production that year?

Some petroleum statistics

Task 3 – different products from oil

We refine oil so that we can use it in different ways and make many different products. Here is a list of different uses, showing their percentage of all refinery products.

Use	Percentage
fuel for cars, buses & lorries	30%
fuel for heating homes, shops & offices	23%
fuel for heavy industry	15%
fuel for generating electricity	11%
fuel for transport by air, sea & rail	9%
starting material for the chemical industry	7%
lubricants, waxes, bitumen products	5%

Draw a diagram to illustrate the different percentages.

Task 4 – the costs, profits & taxes of a petroleum company

In one year an oil company produced 1500 million barrels of oil. This oil was refined and sold for 94000 million dollars, that is $94 billion.

This is what happened to all this money:

cost of the crude oil	$61 billion
taxes paid to the country where the oil was produced	$14 billion
salaries for the 156 000 employees	$4 billion
new investment into plant, research & exploration	$ 7 billion
taxes paid to the processing & consuming countries	$7 billion
dividends to shareholders	$1 billion
Total money spent	$94 billion

Draw a diagram to show how the money was spent.

What were the total profits from the sales of petroleum products?

How were the profits spent?

What are 'dividends to shareholders'? What would happen if this money ($1 billion) was saved or spent on something else?

Could the 'processing country', where the oil is refined, be the same as the 'producing country', where the oil is found? What about the 'consuming countries', where the oil is used; do they have to be different from the producing and processing countries?

When your group has finished all four tasks, look at your set of diagrams and then revise the list you made earlier about why oil is important.

Oil and gas in the ground

Contents

Part A
Rock Oil = Petroleum. The focus is upon rocks – those which are permeable to oil, and which provide the matrix for oil reservoirs and those which are impermeable and can trap the oil. Pupil activities are designed to bring out the meaning of permeability and **porosity**. Part A ends with a practical consideration of where to drill and how to extract the oil.

Part B
How the oil was formed. The story of how oil was created is presented in a simple form, with comprehension questions and a consolidation exercise.

By using the unit pupils will

- identify **properties of materials** which are relevant to a particular context.
- design an experiment, taking account of several variables.
- consider renewable and non-renewable energy sources.

Curriculum focus

Pupils should ... plan & carry through investigations ... with more than one key variable.

Pupils should ... study a range of physical properties ... of materials.

Pupils should be made aware of ... raw materials ... including fossil fuels.

Pupils should consider the origin & accumulation of fossil fuels.

Managing the unit

Activities include sorting, designing & testing, and comprehension exercises.

Two short sections of video are relevant to this unit:

- reservoir formation
- the finding of oil

Teacher notes

Part A
Rock Oil = Petroleum

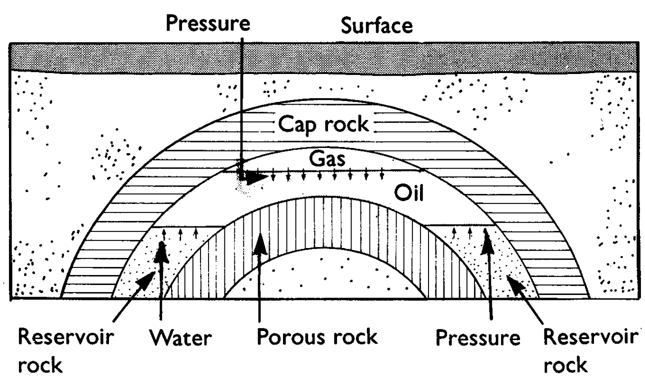
The first activity focuses upon different characteristics of rock samples which can be used as a basis for sorting. Porosity and permeability are highlighted as of importance to petroleum engineers.

A comprehensive kit of rocks, minerals and fossils is available for purchase from:

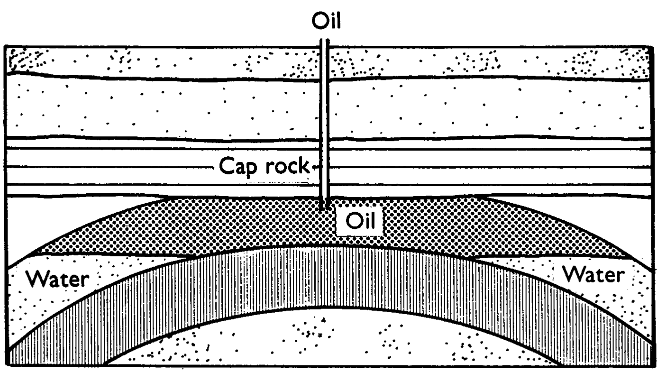
Northamptonshire Science Centre, Spencer Centre, Lewis Road, Northampton, NN5 7BJ.

The kit has been subsidised by the Society of Petroleum Engineers.

The second activity provides a water/sponge analogy to an oil reservoir. The sophistication of the absorbence test will depend on the ability and experience of the pupils. A simple comparison could be made if all three sponge samples were the same size and shape. A more advanced approach would be to find the volume of each sponge and calculate the volume (or mass) of water absorbed per cm^3 Expanded polystyrene is virtually impermeable to water and so it is suggested that the final test is done quickly, without careful measurement.



Gas cap drive



Water injection

A short section of video is relevant to Activity 3:

- reservoir formation.

Answers

The rocks in which oil reservoirs form must be porous and permeable.

Most oil will have seeped away – what is left today is trapped by impermeable rocks.

Part B
How the oil was formed

A short section of video is relevant to this part:

- the finding of oil.

Answers

1 Oil is non-renewable because the time-scale for its formation is so vast.

2 Fossil fuels are non-renewable; nuclear fuel is also non-renewable, even though it can be used more than once in different forms. Solar, wind, wave, and biomass are all examples of renewable energy sources.

3 Fossil remains found in rock samples.

4 The oil and gas would be squeezed into the neighbouring rock strata if these were also permeable.

5 Many differences could be given – including the fact that the oil is not free, like the pool of water, but is absorbed in rock like a sponge.

Rock Oil = Petroleum

> **You will need a set of rock samples.**
>
> 1 Look carefully at the rock samples you have been given, and then sort them into groups. Make notes of your sorting:
>
> - what did you look for?
> - what similarities did you find?
> - what differences were there?
>
> 2 Sort the rock samples into different groups. How did you do your new sorting? What similarities and differences did you choose?

Activity 1

The word 'petroleum' comes from two Latin words: 'petra', which means 'rock'and 'oleum', which means 'oil'. So 'petroleum' means 'rock oil', and we use the word nowadays for the oil and gas we find together in rocks. The 'petroleum industry' is involved with finding the crude oil and gas, getting them out of the ground, and then processing them for sale as a variety of products.

The search for petroleum begins with a study of rocks. You are going to begin in the same way.

It is very important to petroleum engineers to know whether a rock will absorb oil – and, if so, how much oil it will absorb. Two things affect how easily a rock will absorb oil. These are called 'porosity' and 'permeability'. The next activities explain what these words mean and why they are important to the petroleum industry.

Activity 2

a You know that sponges absorb water. This is possible because sponges are 'porous'. The amount of water absorbed is connected with the 'permeability' of the sponge. However, leave the details of 'porosity' and 'permeability' for the next activity. Concentrate on the overall absorbing power of different sponges.

Try this

You are going to find out how much water different types of sponge can absorb.

Use dry pieces of different types of sponge. Think of a way of measuring how much water each can absorb.

Before you start, decide how to make your tests fair.

- What must you keep the same in each test?
- How are you going to wet the sponges?
- How are you going to measure the water they have absorbed?

Before you get your test sponges wet, try this with another piece of sponge.

If you lift it out of the water does any run out? Have you allowed for this in your test plan?

We say that the sponge is 'saturated' when no more water runs out without squeezing.

Rock Oil = Petroleum

Now, finish your plan for the investigation and discuss it with your teacher. When it has been approved you can try it out.

When you have finished, look at your results and answer these questions:

1 Which sponge is the best absorber?

2 Which sponge is the worst absorber?

3 What do you think makes a sponge a good absorber?

Now try the same test on a piece of expanded polystyrene to find out how well it absorbs water.

4 What was the difference in the absorbing power of the sponges and the polystyrene?

5 Look carefully at the structure of the sponges and the polystyrene. Try to explain why the absorbing power of polystyrene is so different from that of the sponges?

Something for you to think about.

6 If oil is absorbed in rock, like water absorbed in a sponge, how can the petroleum engineer get the oil out of the rock?

Activity 3

Sponge and polystyrene have little holes in them. These little holes are called 'pores'. Sponges and polystyrene are called 'porous' materials.

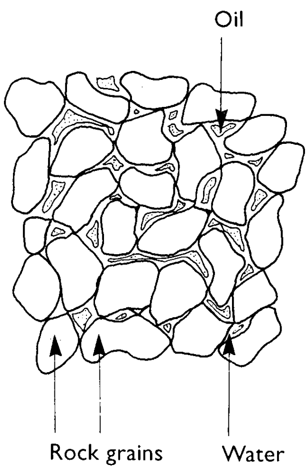
In polystyrene the holes are separated from each other but sponges have tunnels running through them. Water can seep through the tunnels and so we say sponges are 'permeable' to water. Although polystyrene is porous like a sponge, it does not have tunnels because the 'pores' are not connected. Polystyrene is therefore not permeable to water. We say that polystyrene is 'impermeable'.

You remember that petroleum means 'rock oil' because it is found absorbed in rocks. Do you think these rocks will be porous? Will they be permeable?

In many parts of the world oil seeps out of the ground. In 1859 the first successful well was drilled in Pennsylvania (USA), near to an oil seep.

Why do you think all the oil in the world has not seeped away? Why is oil still left in the ground?

Rock Oil = Petroleum



Petroleum is found in the pores of permeable rock, trapped there between layers of impermeable rock. The diagram shows what the different rock layers may be like.

The diagram shows that water is often trapped along with oil and gas. Oil floats on water because it is less dense. Even when they are absorbed in rock, the oil gradually rises to the top and the water sinks to the bottom of the 'reservoir'.

Oil reservoirs are sometimes found deep underground. Some wells have had to be sunk to more than 20 000 ft (well over 6000m) to find oil.

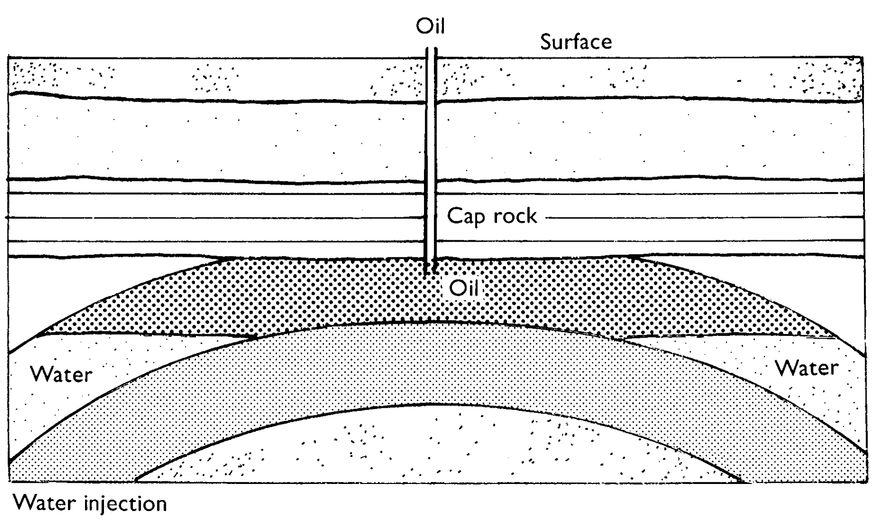
Petroleum has been found all over the world, in all the continents. Sometimes the reservoirs of oil are difficult to get to because they are in inaccessible places – like deserts, seas, and ice fields. On the other hand there can be difficulties in drilling for oil when it is found near to places where people live and work. One example of this difficulty is the oil-field which has been found near to Poole in Dorset, under beautiful heathland and under the sea at Poole Harbour.

Try this

Copy the diagram and show where you would drill a shaft to extract the oil.

At first, the pressure of the gas forces the crude oil out of the ground. Later, the oil has to be squeezed out by pumping a mixture of water and mud into the reservoir to force the oil out of the pores in the rock, and up to the surface.

On the diagram show where you would drill a second shaft through which to pump the mud/water waste from the drilling – the slurry.



How the oil was formed

You have been studying how engineers get petroleum out of the ground. But how did the oil get there in the first place?

Read about how oil was made. You will find some questions in the text – try to answer them as you come to them.

We think that petroleum oil has been formed from plants and animals which lived and died more than fifty million years ago!

1 If this is true, can we make more of this oil whenever we need it? Do you think oil is a renewable, or a non-renewable source of energy?

2 Make a list of five kinds of renewable energy, and five kinds of non-renewable energy.

3 Why do you think scientists estimate that oil's story began fifty million years ago? Where have you found evidence of plants and animals which were alive millions of years ago?

Most of the plants and animals fifty million years ago were growing in the sea, or in fresh water. They died, decayed and sank into the mud and rock particles which lay as a 'sediment' on the sea bed. Over millions of years the sediments piled up in layers. The layers at the bottom were under great pressure from all the layers above. At the bottom there were probably high temperatures, up to 150°C. The high temperature and pressure changed the sediments into rock. We call this type of rock 'sedimentary rock' because it is formed from sediments. Most of the decayed remains of the plants and animals were also changed by the high temperature and pressure into oil and gas.

4 Sedimentary rock has pores running through it. What do you think happened to the oil and gas as they formed?

Rock layers, or strata, look solid and immovable. Over millions of years, movements of the earth's crust can force the rock strata into all sorts of shapes. In this way, the rock strata have been squeezed, moved, twisted and broken. Some of the oil which had been squeezed into permeable rocks became trapped if the earth movements 'capped' the oil-bearing layer with an impervious layer of a different kind of rock on top.

This is what has produced the oil reservoirs.

5 What is the difference between an 'oil reservoir' and a 'water reservoir'?

Now that you have read about how we think petroleum was formed, design and draw a comic strip called 'The story of oil'.

Getting oil from under the North Sea

Contents

Part A
The 'black gold' rush. Pupils take part in an auction of North Sea concessions. (N.B. There are two versions of Part A, the 'alternative' being the easier.)

Part B
Exploration. Pupils study the exploration of a North Sea concession.

Part C
Extraction. Pupils perform an experiment to simulate the extraction of North Sea oil.

By using the unit pupils will

- appreciate that 'hi-tech' investigation is not infallible.
- understand something of the uncertainties which industrialists have to face, and the meaning of 'risk capital'.
- gain a practical understanding of **'immiscibility'**.

Curriculum focus

Pupils should make strategic decisions about the ... accuracy of measurements.

Managing the unit

The oil concession auction can be an individual, or a small group activity.

Teacher notes

Part A
The 'black gold' rush

The details of the oil concession auction are based on the Claymore Oilfield, which was developed by the Occidental Consortium (Occidental 36.5%; Getty Oil 23.5%; Thomson North Sea 20%; and Allied Chemical – North Sea 20%).

The auction may be managed in various ways. Pupils could work as individuals and you could handle the auction yourself. As an alternative, pupils could work in pairs and five pairs could vie with one another, managing their own auction.

There are two forms of Part A. The first depends on a rather complicated business plan. This plan makes it possible to carry out extension work into the background to the figures.

- For example, pupils could be directed to the development costs, which rise to a maximum in 1976. They could be asked to consider how the money would be spent.

  Typical costs are as follows:

  platform development 70%

  pipeline to shore 15%

  landfall facilities 5%

  administration, supply boats, helicopters etc 10%.

- Pupils may be asked why production costs rise after six years.

(Maintenance costs increase as the platform ages.)

- Pupils can work out the cost of a barrel, which underlies the figures. ($30 per barrel.)

The alternative Part A is simplified. It is still based on the business plan but only the results are given, in the table on the second page.

The 'exploration cards' give the idea of a lottery – but the cards are more benign than was actually the case, as reported at the start of part B. (In fact, the Claymore Field had geological problems, with faults, semi-permeable rock strata, and little gas to aid the extraction of the oil.)

Managing the task

Whichever version of Part A is chosen, pupil groups will need several paper resources in addition to the relevant pupil sheets.

Each group of pupils will require copies of:

the map of the North Sea (p34)

the results of the geological survey, with an additional copy to cut into individual 'concessions' as proof of purchase by the highest bidder (p35 & 36)

all the cards (p35 & 36)

Groups tackling the easier 'alternative' version of Part A will have a copy of the analysis table in their pupil sheets, on page 33.

Part B
Exploration

Answers

1 Semi-submersible rigs are used for most of the exploration and appraisal wells. These rigs have their own propulsion systems. In preparation for drilling the rig is securely anchored. Production wells are drilled from platforms secured to the sea bed with 150-foot piles. Thirty six wells are sunk from a single platform, fanning out in a precise pattern by means of directional drilling.

2–5 Drilling mud has a carefully controlled constitution. Four reasons for its importance are listed in the fact sheet, as are the details of directional drilling.

Part C
Extraction

The activity could be used as a lead-in to ideas of immisciblity. Oil and water can be separated using a separating funnel and this may be demonstrated or performed by small groups of pupils. However, that is not possible in an oil reservoir where the oil is absorbed by porous rock.

Answers

The 'water drive' in an oilfield is the injection of water to displace oil from the reservoir rock, and to provide pressure to drive the oil to the surface.

The force, driving the oil up the well, is either the force of the pent-up gas, or else of the injected water in a water drive.

You would have difficulty removing all the oil layer. In fact, you would probably have to use a separating funnel. In situ in an oilfield, it would require not only external pressure (from injected water), but also chemical detergents to free the oil from the rocks.

If you could not see the oil layer in the flask, you would need to test your extract to see if oil was still present.

The final question is rhetorical – if extraction costs escalated to such an extent that they were greater than the income from sales, then the oilwell should be shut down. The only proviso is that it may be worth-while supplying oil at a loss if there is a likelihood of future economically satisfactory sales.

The 'black gold' rush

In 1972, the fourth block of North Sea licences was issued by the British Government. These allowed companies to drill for oil in the North Sea.

Imagine that you are bidding in the 1972 auction for these licences. They will cost you a very great deal of money and we shall try to find out whether, in 15 years time, you will have made a profit or a loss.

1 The concessions

Look at the map of the North Sea.

Shade in licence block 14 in the British sector.

Estimate its length and breadth, and the shortest distance for a pipe-line to land.

The area is divided into 30 smaller rectangles, approximately 10km by 15km. These smaller areas are called 'concessions', and it is these which will be auctioned.

Look at the comments on each of the 30 concessions. These comments are made on the basis of a geological survey of the rocks under the sea bed.

You will have £50 million to spend in the auction and it will be up to you to decide how to spend it.

2 Spending money wisely

Before you decide how to spend your money, look at the rather complicated business plan. The figures are guesses about likely development costs in the years 1974 to 1978, together with the 'revenue' from sales of the oil which you hope to find, and which you hope to sell during the years 1978 to 1987.

In order to make careful decisions, you will need to study the columns of figures in the plan which show how much of the reserve has been exhausted, and what the cumulative balance may be in different years. You can see that in 1974 you will have to spend £65 million drilling exploration wells to find out if oil is present – and if so, how much you may be able to extract (the 'recoverable reserve'). If you are very unlucky you may decide to stop before you spend more money on a poor 'concession'. Otherwise, you will have to spend £585 million developing the oil-field and the pipe-lines before 1978, when you plan to start production and sell your oil.

If you buy a 'concession' which is not very promising, you will be lucky to find more than 50 million barrels of oil. The reserves will be exhausted after 1979 but your sales should have earned £521 million more than you expect to spend on development and production. Government taxes and

The 'black gold' rush

levies will take much of that £521 million, leaving an expected profit of £104.2 million. If you had used your total sum of £50 million in order to buy the one concession there would be an average profit of £9 million per year for the six years from 1974 to 1979. (That would be a very small profit on a risk of more than £600 million in the years 1972 to 1878.)

Even if you are able to buy an extremely promising concession there is no guarantee that it will have vast reserves.

It is wise to buy more than one concession if possible.

3 The auction

The concessions will be auctioned in numerical order, from 1 to 30. If two or more final bids for a concession are the same, then that concession will be withdrawn (this rule is to keep the game moving!)

The highest bidder receives the card as proof of ownership of the concession.

4 Exploration

Having won a concession, your next move will be to drill a number of exploration wells, to search for oil and to find the extent of any oilfield which may exist.

You can explore in the game by using the 10 cards which correspond to the geological description of the concession. Shuffle these cards, then look at the top one. The card will indicate the recoverable reserves found in that concession.

5 The bottom line

This is the last stage in the game, and it is the moment of truth because you will find out if you may be able to make a profit from your investment in the oil concession.

Look again at the business plan.

Underline the point in the 'Reserves' column at which your concession will be exhausted. Note the year at which this will happen. Look at the final column for that year in order to find out your expected profit. (Or, if you have been unlucky, note the loss which is given in the cumulative balance column.)

Express your profit, or loss, as an average for the years from 1974 when you will have been working in the North Sea.

The 'black gold' rush

The business plan *data for the oil game*

Year	Dev't	Prod'n $ m	Cost of dev't $ m	Cost of prod'n $ m	Cumulative costs	Output t.b/d	Annual output m. b	Revenue $ m	Reserves exhausted m. b	Annual balance $ m	Cumulative balance $ m	Profit taxes & levies $ m
1974	Yr 1		65.00		65.00			0.00		-65.00	-65.00	-65.00
1975	Yr 2		162.50		227.50			0.00		-162.50	-227.50	-227.50
1976	Yr 3		195.00		422.50			0.00		-195.00	-422.50	-422.50
1977	Yr 4		162.50		585.00		0	0.00	0	-162.50	-585.00	-585.00
1978	Yr 5	Yr 1	65.00	50.00	700.00	40	14.4	432.00	14.4	317.00	-268.00	-268.00
1979		Yr 2		75.00	775.00	80	28.8	864.00	43.2	789.00	521.00	104.20
1980		Yr 3		80.00	855.00	100	36	1080.00	79.2	1000.00	1521.00	304.20
1981		Yr 4		80.00	935.00	100	36	1080.00	115.2	1000.00	2521.00	504.20
1982		Yr 5		80.00	1015.00	100	36	1080.00	151.2	1000.00	3521.00	704.20
1983		Yr 6		80.00	1095.00	100	36	1080.00	187.2	1000.00	4521.00	904.20
1984		Yr 7		90.00	1185.00	100	36	1080.00	223.2	990.00	5511.00	1102.20
1985		Yr 8		100.00	1285.00	100	36	1080.00	259.2	980.00	6491.00	1298.20
1986		Yr 9		100.00	1385.00	90	32.4	972.00	291.6	872.00	7363.00	1472.60
1987		Yr 10		100.00	1485.00	90	32.4	972.00	324	872.00	8235.00	1647.00

Abbreviations used: $ m = million dollars, t.b/d = thousands of barrels per day, m. b = millions of barrels

The 'black gold' rush

In 1972, the fourth block of North Sea licences was issued by the British Government.

Imagine that you are bidding in the 1972 auction for these licences. That will cost you a very great deal of money and we shall try to find out whether, in 15 years time, you will have made a profit or a loss.

1 The concessions

Look at the map of the North Sea. Shade in licence block 14 in the British sector. Estimate its length and breadth, and the shortest distance for a pipe-line to land.

The area is divided into 30 smaller rectangles, approximately 10km by 15km. These smaller areas are called 'concessions', and it is these which are auctioned.

2 Preparing to spend your money

You cannot be expected to spend money without some indication that oil may be present. A study will have been made of the rocks under the sea bed. It is called a geological survey, and the results are shown as comments on each of the concessions.

Look carefully at the comments on each of the concessions.

You will have £50 million to spend in the auction and it will be up to you to decide how to spend it. Everyone will be interested in the 'extremely promising' concessions but there are only two of these, and the bidding may go up beyond your £50 million. Concessions 1 to 12 may go cheaply because others may be waiting for the more promising areas from 13 to 24.

It is wise to buy more than one concession if possible.

3 The auction

The concessions will be auctioned in numerical order, from 1 to 30. If two or more final bids for a concession are the same, then the bidding is assumed to go above your limit and that concession will be withdrawn from the game.

The highest bidder receives the card as proof of ownership of the concession.

4 Searching for your own part of an oilfield

Having won one or more concessions, the next move will be to search for oil in each one. You will drill a number of exploration wells, in order to search for oil and to find the extent of any oilfield which may exist.

The 'black gold' rush

Consider your concessions one at a time. Select the set of cards which corresponds to the geological description of your concession.

Shuffle these cards, then look at the top one. The card will indicate the recoverable reserves which you have found in your concession.

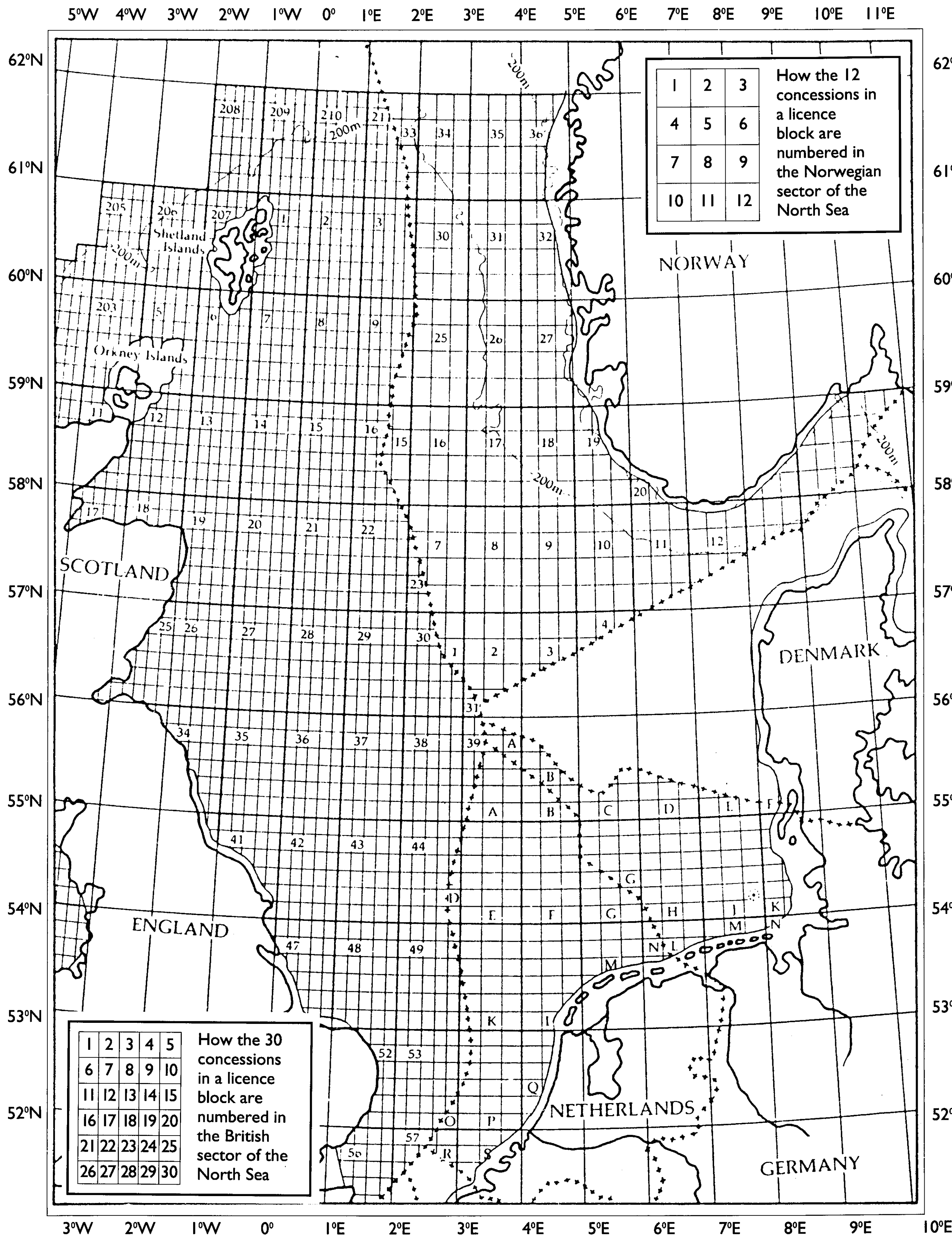
5 The bottom line

This is the last stage in the game, and it is the moment of truth because you will find out if you may be able to make a profit from your investment in the oil concession.

Look at the table below and find out your profit or loss.

Exploration finding	Years of development	Years of production	Profit or loss
No oil found	1 (After one year's exploration, the area would be abandoned)	0	-£65 million
Fewer than 20m barrels	2 (After two years' exploration, the area would be abandoned)	0 (After one year's production the oil would have dried up)	- £227 million
20m to 50m barrels	5	2	+ £104 million
50m to 200m barrels	5	6	+ £904 million
At least 400m barrels	5	10	+ £1647 million

The ‘black gold’ rush



Map of the North Sea showing sectors and how they are divided into licence blocks and concessions.

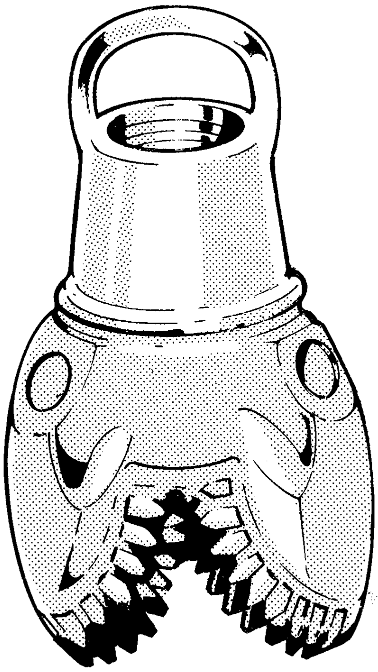
The ‘black gold’ rush

1 Not at all promising	20 m. to 50 m. barrels	**2** Not at all promising	50 m. to 200 m. barrels	**3** Not at all promising	50 m. to 200 m. barrels
4 Not at all promising	50 m. to 200 m. barrels	**5** Not at all promising	50 m. to 200 m. barrels	**6** Not at all promising	At least 400 m. barrels
7 Not very promising	Fewer than 20 m. barrels	**8** Not very promising	20 m. to 50 m. barrels	**9** Not very promising	20 m. to 50 m. barrels
10 Not very promising	20 m. to 50 m. barrels	**11** Not very promising	50 m. to 200 m. barrels	**12** Not very promising	50 m. to 200 m. barrels
13 Quite promising	Fewer than 20 m. barrels	**14** Quite promising	Fewer than 20 m. barrels	**15** Quite promising	Fewer than 20 m. barrels

The 'black gold' rush

16 Quite promising	Fewer than 20 m. barrels	17 Quite promising	20 m. to 50 m. barrels	18 Quite promising	20 m. to 50 m. barrels
19 Very promising	No oil found	20 Very promising	Fewer than 20 m. barrels	21 Very promising	Fewer than 20 m. barrels
22 Very promising	Fewer than 20 m. barrels	23 Very promising	Fewer than 20 m. barrels	24 Very promising	20 m. to 50 m. barrels
25 Very promising	20 m. to 50 m. barrels	26 Very promising	20 m. to 50 m. barrels	27 Very promising	20 m. to 50 m. barrels
28 Very promising	20 m. to 50 m. barrels	29 Very promising	At least 400 m. barrels	30 Very promising	At least 400 m. barrels

Exploration



The game you have played is based on the discovery and development of an actual oilfield, the Claymore Oilfield. It is located in the British block 14, and spreads over the concessions 18 and 19 in particular. (The costs and revenue figures used in the game are made up.)

Look again at the geological survey comments on Block 14. Both concessions 18 and 19 are said to be 'extremely promising' – the most likely areas for finding oil. In Summer 1972, the first exploration well was drilled - in concession 19. It was drilled to 9500 ft but there was no evidence of commercially viable reserves of oil or gas.

It was not until 7 April 1974 that a second well was drilled, again in area 19. This well was sunk to 10 587 ft, at a cost of $3.5 million. It was successful! Seven more exploration wells were drilled, some with encouraging results, some with bad. Claymore was quite obviously going to be a difficult field to develop. But the risk was taken, the field was developed and a platform was erected 500 feet above the sea bed, 60 feet above the surface of the sea, and with a super-structure rising 150 feet above that. Thirty wells were drilled from the platform, 20 for the extraction of oil, ensuring a production of between 80 000 and 100 000 barrels per day, and an expected life-time for the field of about 20 years.

1 *How are wells drilled in the North Sea?*

2 *Why is 'mud' pumped down to the drill bit during the drilling?*

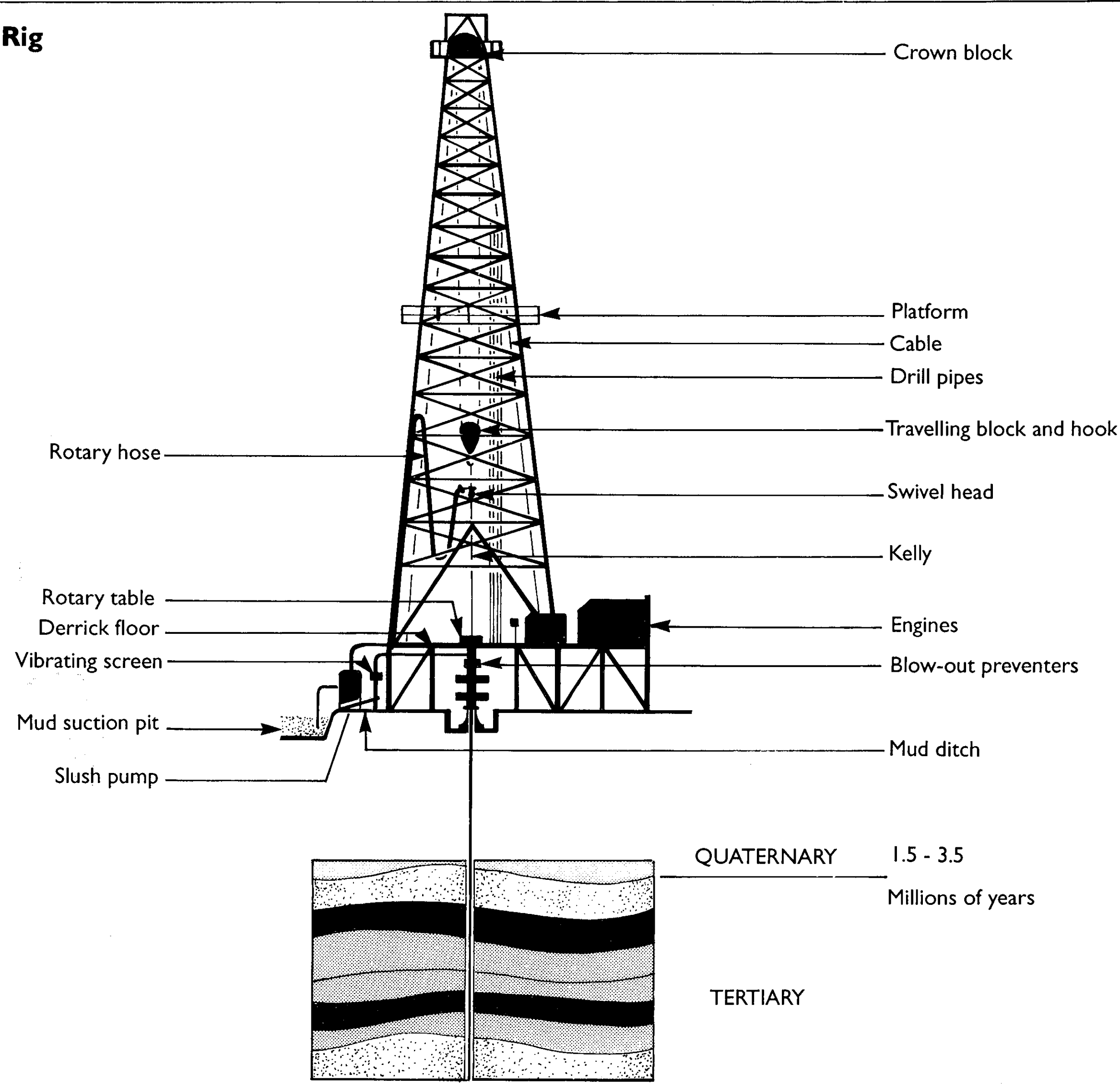
3 *What is 'directional drilling'? Why is it used in the North Sea? Why was it not used in the early days of land drilling?*

You probably have several ideas about possible answers to some of the questions above. The Fact Sheet has information which will help you further.

Exploration

Fact sheet

Drilling Rig



An electric drill has a 'bit' which actually makes the hole when it is spun round by the electric motor.

What different kinds of 'bits' are available for home repairs?

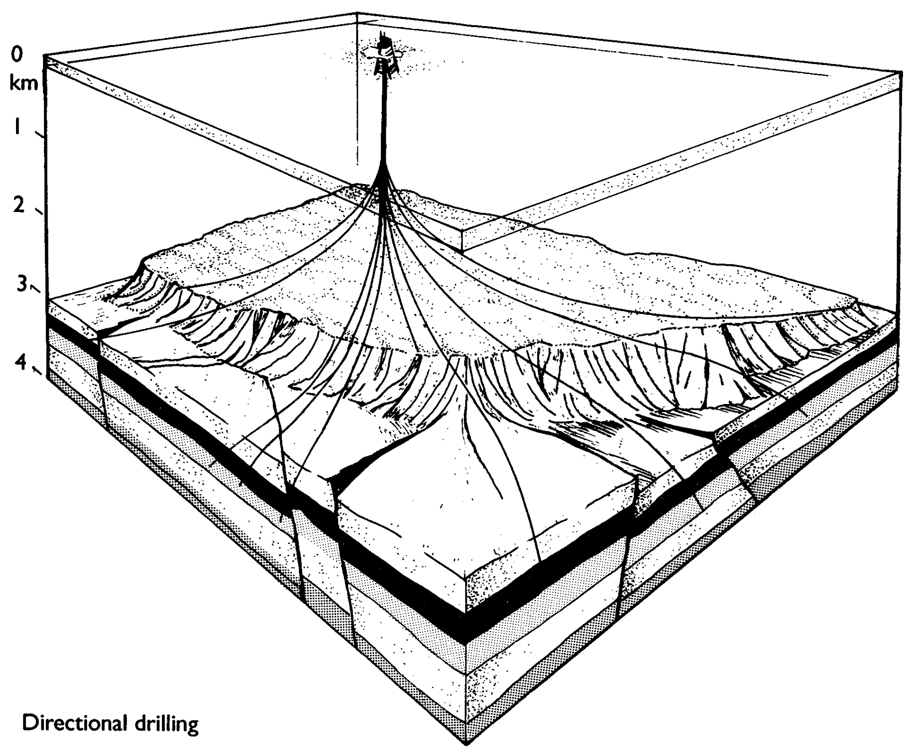
An oil rig has different kinds of 'bits' to drill into different types of rock. The bit is spun round by powerful diesel engines. As the hole gets deeper, drilling has to stop in order to add extensions to the steel pipes attached to the bit. If the bit has to be changed, drilling has to stop for several hours in order to withdraw the entire drill 'string' (as it is called). Drilling 'mud' is pumped down the string of pipes to the bit. The mud comes out through holes in the bit and returns to the surface around the outside of the pipes. The mud is a suspension of a special clay in water.

Exploration

Drilling mud

- cools the drill bit.
- makes it solidify, preventing the wall of the hole, which is being drilled, from caving in.
- carries the drilled out rock fragments to the surface.
- helps to prevent a breakthrough of liquids and gases into the borehole from the reservoir when the bit enters the reservoir. (If this does happen, it can be very dangerous because it can lead to a blow-out.)

To avoid erecting a separate platform for each well, 'directional drilling' is carried out from a single platform.



Directional drilling

Look at the diagram above – although two of the well heads may be less than three metres apart at the platform, at the bottom of the wells, where they enter the reservoir, they may be eight kilometres apart! There may be 36 wells from one platform. Most of these wells are for extraction of oil or gas but some are needed for injecting water under pressure (see Part C for a further explanation). The Piper platform needs only four of these wells for water injection, whereas Claymore uses eight.

Directional drilling is now used onshore, especially in environmentally sensitive areas. For example, there is an oil reservoir underneath Goodwood Racecourse in Sussex, but the wellheads, through which oil is produced, are located over a kilometre away in a woodland area.

Extraction

When an oil or gas field is discovered, the petroleum must be extracted in a controlled way. Some reservoirs are at such a high pressure that, once a well is drilled, oil and gas are forced to the surface by the pressure in the reservoir. Control valves are fitted to keep the flow to a suitable rate.

In Kuwait, 500 wells which were damaged in the 1991 Gulf war were in this type of reservoir. Once the control valves had been damaged by explosives the oil and gas rushed out at high pressure – and on fire! These wells had to be 'capped'.

As the oil, and particularly the gas, is removed, pressure decreases and oil will cease to flow. This means that pressure must be exerted from outside. To maintain the flow, filtered sea water is forced into the reservoir to replace the oil.

To obtain the best rate of flow, a number of wells are drilled to different parts of the reservoir. Different fields require different numbers of these wells to be used for injecting sea water to drive the oil out of the other wells.

Try this

Activity 1

You will need

$250\,cm^3$ conical flask containing oil and water

filter funnel

delivery tubes *x* and *y*

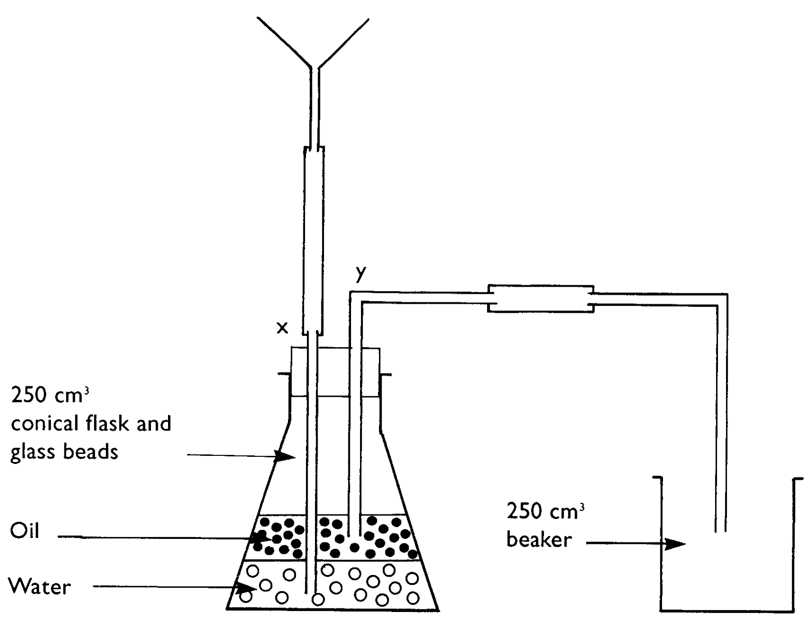
$250\,cm^3$ beaker

glass beads

another beaker

Set up the apparatus as shown in the diagram below. Tube *x* must be in the water and tube *y* in the oil in the flask.

The contents of the conical flask represent the layers of water, oil and gas in a reservoir. The glass beads stand for the porous and permeable rock that the petroleum is found in.



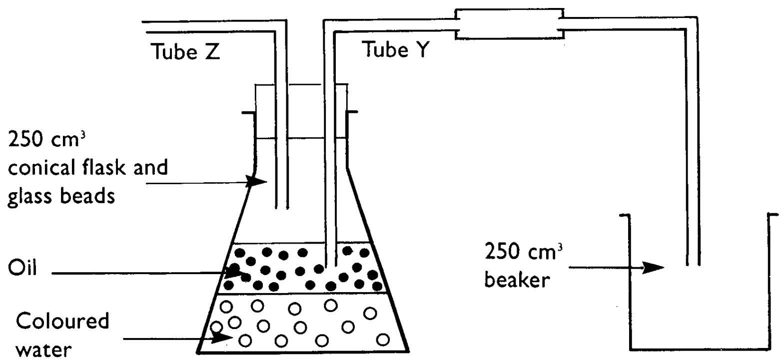
- Pour water from another beaker into the funnel.
- *What happens?*
- *This sort of thing is called a water drive on an oil field. How would it work there?*

Extraction

Activity 2

Keep your apparatus except change delivery tube *x* for delivery tube z.

Set up the apparatus as shown in this diagram. Check that tube z does not reach the oil layer, and tube y reaches about half way down through the oil layer.



- Take the usual precautions then blow into tube *x* until nothing else happens.
- *What did happen?*
- *What force pushed the oil up from the 'well'?*
- *Could you remove all the oil layer?*
- *If yes, how? If no, why not?*
- *If you could not see the flask, how would you know when you had got out as much oil as possible?*

A few more facts

If oil in the ground was in a 'hole' like being in a flask, applying a pressure should eventually force all the oil to the surface. In fact, it requires more and more pressure, and eventually chemical detergents to free the oil from the rock. It therefore costs more and more money to extract the oil.

If it costs more to extract the oil than oil can be sold for – what do you think will happen?

A few more facts

If oil in the ground was in a 'hole' like being in a flask, applying a pressure should eventually force all the oil to the surface. In fact, it requires more and more pressure, and eventually chemical detergents to free the oil from the rock. It therefore costs more and more money to extract the oil.

If it costs more to extract the oil than oil can be sold for, what do you think will happen?

It is often only about 30% of the oil in a reservoir that is economically worth extracting. The amount that can be economical to extract is known as the 'recoverable reserve'.

Even if it cannot be recovered economically, it is still a potential 'resource'.

If, because of economic changes, or changes in technology, oil which formerly could not be recovered becomes recoverable, a resource may become a reserve. Reserves of all mineral commodities may change frequently. This is often due to new discoveries. Before the 1960's, there were no petroleum reserves in the North Sea because none had been discovered.

If the oil price decreased drastically, reserves might suddenly get smaller because the oil could not any longer be recovered economically. This means the potential resource will be larger.

Oil platforms are workplaces

Contents

Part A
'Jobs for the boys'. Pupils start by considering jobs which have to be done on oil platforms and then question assumptions about the exclusion of women from these and other workplaces.

Part B
Gassy liquids. Ways of separating gases from liquids, and liquids from liquids, provide opportunities to develop scientific principles underlying solubility and miscibility. The unit ends with a consideration of the problems, for divers, of gases dissolved in blood.

By using the unit pupils will

- have an opportunity to question assumptions.
- consider the behaviour of **gases dissolved in liquids** at different pressures.
- consider blood as a transport system in the body.

Curriculum focus

Pupils should learn how to separate and purify the components of mixtures.

Pupils should investigate changes of state.

Managing the unit

Most of the work of Part A is individual. In the second part, small groups of pupils carry out literature searches and contribute their findings to the group.

Teacher notes

Part A
'Jobs for the boys'

This unit gives an opportunity to review work which has been covered in the previous four units. Pupils may be given about ten minutes to list up to ten jobs they would expect to find on an oil platform – that is question 1 on the pupil sheet. Question 2 could well be discussed by pairs of pupils, comparing oil rigs with other traditionally 'men only' work situations which have eventually been opened to women. (Examples could include recent moves to include women on the ships of the Royal Navy, the armies in several countries, mining in the USA, senior positions in the police, banks, and secondary schools, and perhaps to look back to the historic battles of women to be admitted to the male world of medicine.)

Before they attempt the third question, each pupil should compare their own list of jobs with that given in the fact sheet.(The second part of the question could be used to lead into a discussion of the stereotyping of jobs by the names we use for them – e.g. Postman, Chairman, Lord Mayor, etc.)

Part B
Gassy liquids (and how to separate them)

Mixtures of gases in liquids, and also mixtures of immiscible liquids, provide a lead-in for the mainstream science of separation techniques. Solubility, immiscibility, and in particular the variation of solubility of gases with pressure can all be developed after this introduction. The example of gas dissolved under pressure in oil is developed in the unit. However, the solubility of gases such as oxygen, nitrogen, and helium in blood is only introduced – allowing further work on both the physical properties of gases and liquids, and the biological aspects of respiration and the role of blood as a transport system in the body.

Respiration takes place in the cells of our bodies. The reactions which occur are very complex. However, it is often simplified and compared to the burning of a fuel, because the starting materials are foodstuffs such as carbohydrates and the gas oxygen. The final products of respiration are water and the gas carbon dioxide. Air is breathed into the lungs and some oxygen and nitrogen are dissolved in the blood as it passes through parts of the lung wall. The blood carries the gases round the body to the different cells, giving up oxygen for respiration to take place. At the same time, the blood picks up the waste products and carries these back to the lungs to be breathed out as exhaled air, with a higher concentration of carbon dioxide and water vapour. So it can be seen that blood always has gases dissolved in it.

The problems occur for divers because the pressures are so very much greater than atmospheric and much more gas dissolves than normal. It is just like a bottle of lemonade – far more carbon dioxide is forced to dissolve under considerable pressure. When the lemonade bottle top is removed, exposing the liquid to normal atmospheric pressure, the extra gas fizzes out of the solution. If the gases were allowed to suddenly fizz out of blood, the diver would be in danger and might die because the bubbles of gas in the blood-stream would interfere with the pumping of the heart.

Deep sea divers breathe a mixture of oxygen and helium. Helium gas replaces the nitrogen which is present in air because helium is less soluble and would not produce so many bubbles. However, it is still necessary for the divers to return very slowly to the surface (or to be kept isolated in their artificially high pressure container until the pressure has been slowly reduced to normal – a process which can take some time). Breathing helium instead of nitrogen has a strange effect on the human voice, making it high pitched and squeaky.

'Jobs for the boys'

The first unit of this series compared an oil platform to 'A town in the North Sea. It was quite clear that in order to maintain life in such an isolated community of about 70, there was a need for a great many different jobs to be done. The catering manager and the cooks are important to everyone.

1 *Quickly list up to ten other jobs which you think will be needed on the platform.*

2 *At present, all these tasks are done by men. Why do you think women are not employed on oil rigs? What do you think needs to change for women to become rig workers?*

3 *Compare your list of jobs with the list given in the fact sheet. The names of some of the jobs are unusual – and some would have to be changed if women were to share them. What changes do you suggest?*

'Jobs for the boys'

The drilling superintendent is in overall charge. The specific responsibility is to see that the drilling programme is accurately carried out.

The tool pusher is second to the drilling superintendent. The tool pusher is responsible for day-to-day operations. It is the tool pusher who must see that the correct equipment is available when and where it is needed.

The driller leads a drilling crew of roughnecks and roustabouts.

The derrick man works in the derrick, above the main drilling platform (called the drilling floor). The derrick man is in charge of handling all the steel pipes and drilling bits as they are needed.

The roughnecks do much of the manual work for the driller, working mainly on the drilling floor.

The roustabouts carry out manual jobs wherever they are needed.

The welders and the **electricians** are specialists in their own skilled trades.

The radio operators maintain communications with the shore, helicopters, supply and safety ships, and the entire platform.

The medic looks after straightforward health enquiries and treats most minor injuries.

The barge master is like the captain of a ship and is responsible for the seaworthiness of the platform.

The ballast man works for the barge master, keeping a check on the stresses on the legs of the platform as heavy loads are moved from one area to another. The ballast man controls ballast tanks, which are filled with water, or emptied to compensate and re-balance the whole system.

The crane operator has a job which is very different from crane operators on shore. When stores and equipment are being lifted by crane onto the platform, the supply vessel may be heaving and rocking unpredictably in the North Sea waves.

The divers are usually employed by a special company, and are then contracted to the company operating the rig.

Cooks and stewards look after the living quarters.

Gassy liquids

Activity 1 Oil and Gas

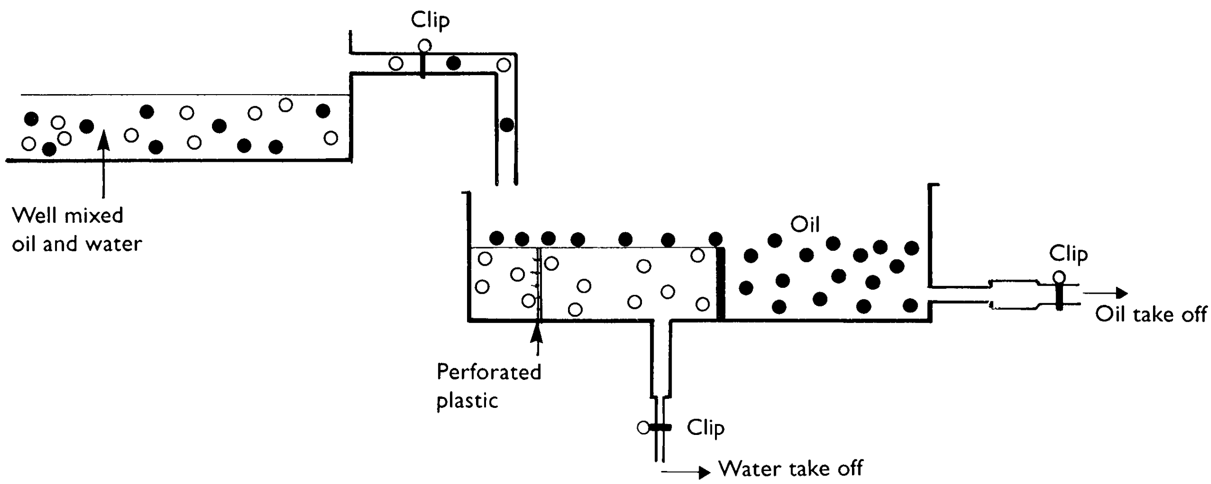
In Unit 4, the extraction of oil was described. Natural gas helps drive the oil to the surface and high pressure water completes the process. (Can you remember what proportion of the oil is extracted?)

If it was suddenly released, the oil/gas/water mixture would shoot up out of the well, frothing uncontrollably.

Look carefully at a sealed bottle of 'fizzy water'. Is it really fizzy? What makes it fizz? Can you make it fizz more? What makes the water 'un-fizzy'?

In Unit 4, a separating funnel was used to separate a small amount of oil and water.

Design an apparatus which could be used in the North Sea to separate gas and water from the oil.



Activity 2 Blood and gas

Underwater parts of the platform and pipelines have to be inspected, to make sure that they are safe, and to carry out maintenance and repairs. Divers go down to depths of hundreds of feet, where pressures may be more than ten times greater than that at the surface. (At 100 feet, the pressure is more than three times normal atmospheric pressure.) You have probably studied the blood in our bodies and will know that it dissolves different gases in order to carry them from the lungs to the cells, and to carry slightly different gas mixtures back again to the lungs.

1 *Find out what could happen to the gases dissolving in a diver's blood at great depths.*

2 *Find out what would happen if the diver came straight up to the surface after working at a depth of several hundred feet.*

3 *Find out how divers are able to breathe safely at very great depths, and to return to conditions at normal atmospheric pressure without suffering.*

Gassy liquids (and how to separate them)

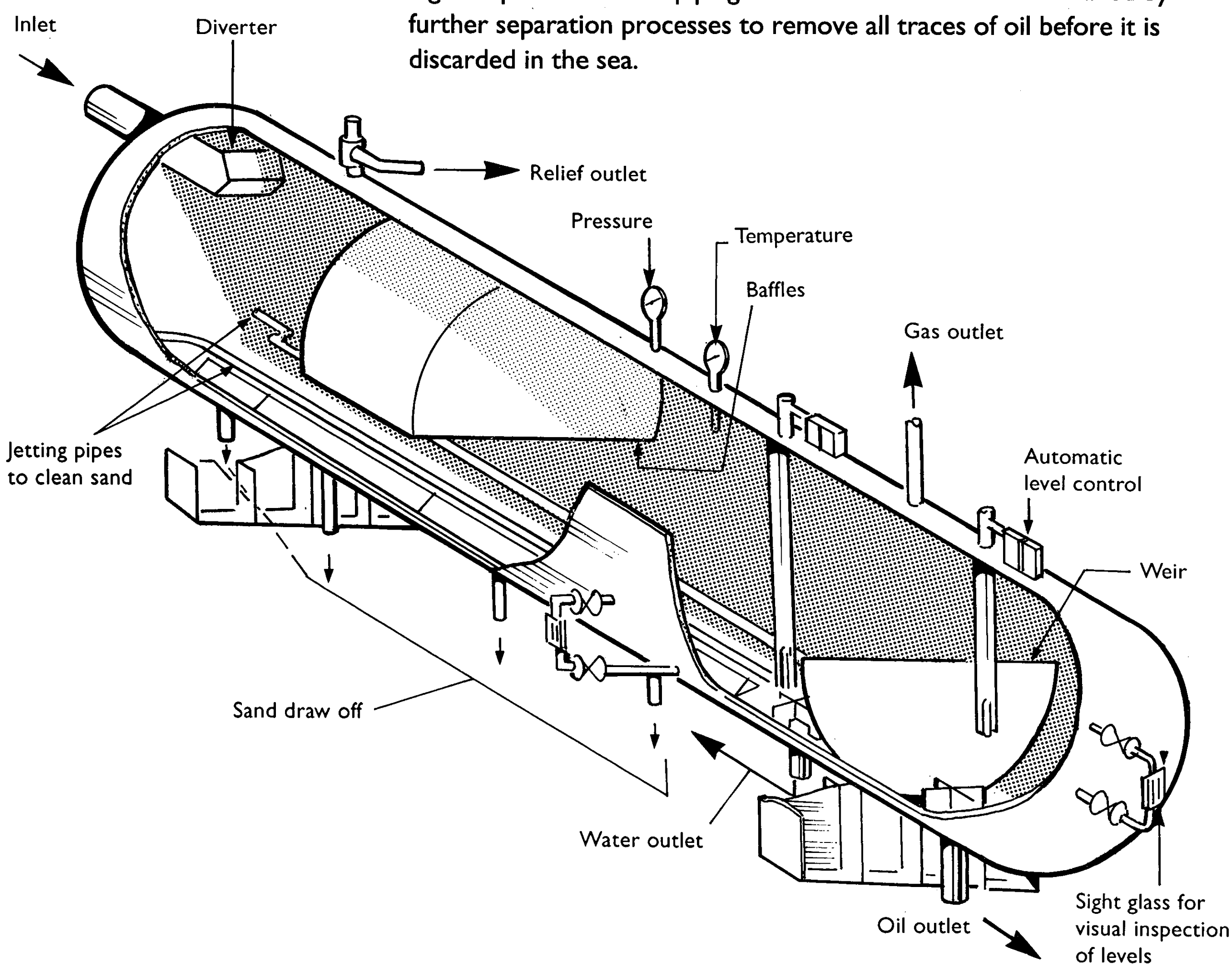
Separating oil, gas, and water during continuous production

An off-shore well will produce between 1000 and 35000 barrels per day. Look back to Unit 2, Part B, to see what size of tank would be needed to hold 1000 barrels of oil.

The mixture of oil, gas, and water is driven up the well and passed through a series of three enclosed tanks. The pressure is reduced as the mixture travels through each tank. The tanks are fitted with a series of baffle plates which help the gas escape and cause the liquids to form into separate droplets of oil and water.

As the gas escapes, it is used to power the electricity generators and the water de-salination plants on which the rig depends. If there is sufficient gas, it is piped ashore as part of the natural gas supply. Otherwise the remainder is burnt at a 'flare stack' attached to the platform.

Inside the tanks, water sinks gradually to the bottom. (What is the approximate density of water, sea water, and oil?) The water is run off from the bottom of the tanks. Oil floats on top of the water and is run off higher up the tanks for piping to the shore. The water is cleaned by further separation processes to remove all traces of oil before it is discarded in the sea.



Contributors

Oil from beneath the sea

Eileen Barrett, Recruiting Consultant, Department of Mineral Resources Engineering, Royal School of Mines; Alison Dennison, Mandale Middle School, Bradford; Ian Phillips, the Society of Petroleum Engineers; John Slade, SATIS

Acknowledgements

Shell UK Ltd. and the Shell Film and Video Unit for permission to reproduce video material.

Phillips Petroleum for permission to reproduce material from *Ekofisk – one of a kind*; the Occidental North Sea Group for illustrations from *The search for North Sea oil*, *The Claymore story*, and *The Flotta story*

BOOK 7 UNITS

A series of related units on the application of science and technology to a major industry.

A town in the North Sea
Investigating the logistics of maintaining a North Sea oil rig

Petroleum – the raw material
Understanding the growth of the oil industry

Oil and gas in the ground
Exploring the properties of materials

Getting oil from under the North Sea
Simulating oil extraction

Oil platforms are workplaces
Investigating the separation of liquids and gases; questioning the all-male workplace

SATIS 8-14

Box 3