Trapped! Why can't oil and gas escape from their underground prison?

Demonstrate how oil and gas can be trapped in reservoir rocks beneath the surface

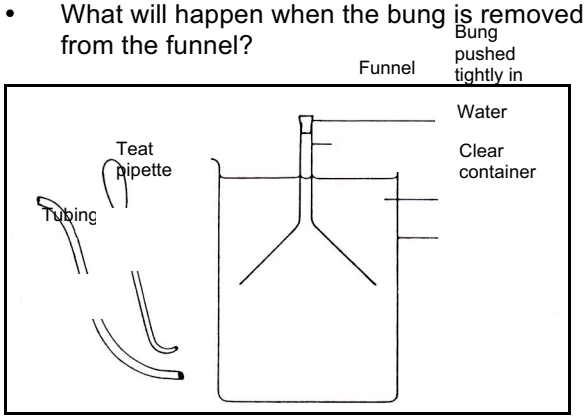
Set up a model to demonstrate the principle of an oil and gas trap. Either make up the laboratory version, as in the diagram, or the home-made version, as in the photographs. In either case, push the funnel well down into the water in the container and only then seal the top part of it with a bung.

Blow air underneath the lip of the funnel with a piece of tubing or bent pipe, to represent gas, displacing roughly half the water. Put some cooking oil into the tubing and blow it up into the inverted funnel, to represent oil.

Explain that the inverted funnel (or the top of a clear plastic bottle) represents the impermeable cap rock forming a trap in a permeable layer containing natural gas and oil.

Ask the pupils:

- In which order do the different 'layers' of gas, oil and water occur?
- Why do the gas and oil lie on top of the water and not the other way round?
- Are the bases of the 'layers' of gas and oil above the water horizontal or not?
- What will happen when the bung is removed from the funnel?



Laboratory apparatus for carrying out the activity

Then, remove the bung sharply and see what happens.

- Ask why this might be a problem in a real oil or gas well.

Note: If no cooking oil is available – the principles can be demonstrated using only the air blown through the tubing.

Home-made apparatus showing the model oil trap in action

Home made funnel using the top of a bottle, a tube from a ball point pen and some clay *(Photos: P. Kennett)*

The back up

Title: Trapped! Why can't the oil and gas escape from their underground prison?

Subtitle: Demonstrate how oil and gas can be trapped in reservoir rocks beneath the surface

Topic: The principle of how a natural underground trap for oil and natural gas works

Age range of pupils: 14-18 years

Time needed to complete activity: 10 mins

Pupil learning outcomes: Pupils can:

- explain that oil and gas float on top of water, because of their lower density;
- explain that oil and gas may become trapped underground, if they rise up until they reach an impermeable layer of rock;
- appreciate the need to control the drilling for oil and gas, to avoid 'blowouts' at the surface.

Context: This could form part of a lesson on the world's resources. It could follow a lesson on porosity and permeability.

Answers to the questions above are as follows:

- In what order do the different 'layers' of gas, (oil) and water occur? *Gas (on top), oil (in the middle),water (at the bottom).*
- Why does the gas (and oil) lie on top of the water and not the other way round? *The density of gas is less than that of water. Oil is a lot denser than gas, but of lower density than water.*
- Are the bases of the 'layers' of gas and oil above the water horizontal or not? *The junctions between the various fluids are horizontal. This may seem obvious, but*

pupils frequently think that the junctions follow the curve of the beds of rock in which they occur.

- What will happen when the bung is removed from the funnel? *The gas blows out of the narrow part of the funnel into the atmosphere. If the bung is removed sharply enough, the underlying oil and/or water may escape with a spurt, too.*
- Why might this be a problem in a real oil or gas well? *If it is not controlled, the 'blowout' of oil/gas can wreck the drilling equipment; oil might escape and pollute the environment. Uncontrolled natural gas could easily catch fire. In the early days of oil and gas exploration, such 'gushers' were common, but modern control methods mean that they are now extremely unusual.*

Following up the activity:
It is very important that pupils are not left with the notion that water, oil and gas occur in vast underground lakes. Instead, these fluids are held in the pore spaces between the grains that make up a sedimentary rock. This may be demonstrated by slowly dripping water onto a porous sandstone, or onto a piece of dried out mud and watching the water soak in. Other activities in the Earthlearningidea series also deal with this topic (See 'Useful Links' below). Pupils might investigate the underground resources of water, oil or natural gas of their own country from web searches.

Underlying principles:
- Oil and natural gas are formed underground from organic material buried millions of years ago – the 'source rock'.
- If the surrounding rocks are permeable, they will be full of water. The oil and gas, having lower density, rise upwards through the water
- They can be trapped by an impermeable 'cap rock' if it is in a 'trap' shape.
- The porous rock in which they are trapped is the 'reservoir rock'.
- Oil and gas do NOT occur in underground lakes, but are held within the pore spaces in the rock.
- The model is intended to focus on the properties of the cap rock and the trap (the funnel or bottle), and not the space beneath, which, if taken literally, would represent a rock of 100% porosity!

Thinking skill development:
- appreciation of the density pattern of water, oil and gas (construction);
- what will happen if…? and comparison of the model with reality (cognitive conflict);
- reasoning behind the answers (metacognition);
- applying the model to real situations in oil exploration and other occurrences where density differences are important (bridging).

Resource list:
a) Laboratory version
- large glass beaker e.g. 2 litre, nearly full of water
- large glass funnel, with small bung to fit the small end
- clamp, stand and boss, to hold funnel down
- glass teat pipette, with a bent end (done by heating in a Bunsen flame)
- drinking straw or tubing for blowing air into the funnel
- cooking oil

b) Home-made version
- any large container, e.g. a bucket, preferably with clear sides, nearly full of water
- top end cut off a clear plastic bottle (e.g. 2 litre bottle)
- thin tube, e.g. the barrel of an old ball-point pen
- clay, to seal the tube into the neck of the bottle end
- drinking straw or tubing for blowing air into the funnel
- cooking oil (if possible)

Useful links: Try the Earthlearningidea activities *'Modelling for rocks : what's hidden inside and why*', published 1st December 2007: '*The space within: the porosity of rocks'*, published 30th June 2008 and '*Where shall we drill for oil? Sorting out the sequence - oil prospect,* published 8th September 2008.

Source: Earth Science Teachers' Association (1992) *Science of the Earth 11-14 Power source: oil and energy.* Sheffield: Geo Supplies Ltd., and based upon an original idea by D.B. Thompson.