Reservoirs and Production

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Lesson Plan – Page 1

Secondary Pupils

Topic: Reservoirs and production

Topic Overview: Porosity refers to the percentage of holes (pores) in the rock. Permeability is the ability of fluids to travel through porous rocks. If a well is to be successfully produced, the reservoir must have porosity, permeability and enough pressure to move the oil and natural gas to the well bore.

Activity Overview: Pupils will investigate porosity and relate it to the processes involved in extracting oil.

Core Experiences and Outcomes:

SCN 2-17a: Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses.

SCN 3-17b: I have participated in practical activities to extract useful substances from natural resources.

Learning Intention:

I am learning about different types of rocks and their importance during oil production.

Success Criteria:

I can explain what porosity means and how it affects our ability to extract oil and natural gas from reservoirs.

Resources

Reservoirs and Production Experiment Record

Book Reference:
Oil and Natural Gas,
pages 24-27

Materials for Introductory Activity:

- Marble cake
- Clear plastic straws

Materials per group for Main Activity:

- 1 bag large gravel
- 1 bag small gravel
- 1 bag sand
- 1 100 ml measuring cylinder
- 3 500 ml beakers
- Water coloured with food dye

Key Vocabulary

Sedimentary rock – rocks formed from material deposited as sediment by water, wind, or ice and then consolidated by pressure

Permeability – The ability of liquids and gases to move through pore spaces in rocks.

Porous – Having a surface that contains pores (tiny holes) or a body that contains cavities.

Porosity – The ratio of the space taken up by the pores in a soil, rock, or other material to its total volume. It is expressed as a percentage.

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Teacher Information:

Read to pupils from Oil and Natural Gas, pages 24-45:

'When oil companies drill for oil, they look for oil traps. These are places where oil collects underground after seeping up through the surrounding rocks. This slow seepage, called migration, begins soon after liquid oil first forms in a "source" rock. Shales, rich in solid organic matter known as kerogen, are the most common type of source rock. The oil forms when the kerogen is altered by heat and pressure deep underground. As source rocks become buried ever deeper over time, oil and gas may be squeezed out like water from a sponge and migrate through permeable rocks. These are rocks with tiny cracks through which fluids can seep. The oil is frequently mixed with water and, since oil floats on water, the oil tends to migrate upward. Sometimes, though, it comes up against impermeable rock, through which it cannot pass. Then it becomes trapped and slowly accumulates, forming a reservoir.'

pages 26-27:

'Most of the oil the world uses is black, liquid crude oil drawn up from subterranean formations. Yet this is just a tiny fraction of the oil that lies below ground. A vast quantity of more solid oil exists underground in the form of oil sands and oil shales. Oil sands (one known as tar sands) are sand and clay deposits in which each grain is covered by sticky bitumen oil. Oil shales are rocks steeped in kerogen- the organic material that turns to liquid oil when cooked under pressure. Extracting oil from oil shales and oil sands involves heating them so that the oil drains out. At the moment, it is unconventional, but many experts believe that when crude oil reserves begin to run out, oil shales and oil sands may become our main sources of oil.'

Additional Information:

Some sedimentary rocks are porous, like a sponge. Tiny particles of sand are held together with in the rock. Pressure, time and sediments create this natural type of 'cement.'

Oil and natural gas are formed from decayed plant and animal material. Over time, the many layers of sand and sediments are compacted into sedimentary rock. Tiny spaces, or pores, exist between the particles that enable the rock to hold a liquid. Oil and natural gas become trapped inside the pores. Many pores may be connected to form a pore passage. Rocks that contain pores and more passages are identified as porous and permeable. Permeability is the ability of liquids and gases to move through pore spaces in rocks. A rock may be porous and permeable. A rock may be porous, but if the pore spaces are not connected together, the liquids will not be able to pass through the rocks.

Through drilling and pumping, oil and natural gas are extracted from the inside of porous rock. This is contrary to the belief that oil is formed in puddles or pools underground.

Establishing Prior Knowledge

- How does oil and natural gas exist underground? In tiny pockets in rocks or in big puddles or pools?
- How do we get oil and natural gas out of the ground?
- What is a pore?
- What is porosity?

Concept Introduction

Porosity refers to the percentage of holes (pores) in the rock. Permeability is the ability of fluids to travel through porous rocks. If a well is to be successful, the reservoir must have porosity, permeability and enough pressure to move the oil and natural gas to the well bore.

Introductory Activity

Purchase or bake a marble cake. Make sure the dark layer cannot be seen from the surface of the cake or ice the cake so the colours of the layers cannot be seen.

Using a clear plastic straw, take a core sample from the cake. Ask pupils to make predictions of what the cake looks like inside. What kind of cake might this be? Explain that you just took a core sample out of the cake. Tell pupils that in this lesson we are going to learn how geologists look at core samples of the earth and determine the porosity and permeability of the rock that is beneath the surface. Trying to "see" what is beneath the surface of the Earth is one of the jobs of a geologist. Rather than digging up vast tracts of land to expose an oil field, core samples can be taken and analyzed to determine the likely composition of the Earth's interior. The geologist cannot go down into the well to see the rock since the hole is only about 20" in diameter at the surface. But, the geologist can ask for a core sample.

Core samples can be studied to see how much liquid is in the pores of the rock. This is a study of the rock's porosity. Measuring the volume of oil in the pores allows a geologist to determine the rock's level of oil saturation. Since oil is found in pores in the rock, not in caves, these measurements are important!

Main Activity:

Split pupils into groups. Provide each group with materials shown on Page 1 and the Experiment Record which outlines the procedure below:

1. Fill one beaker to the 350 ml mark with large gravel.
2. Fill another beaker to the 350 ml mark with small gravel.
3. Fill a third beaker with 350 ml of sand.
4. Fill the graduated cylinder with 100 ml of the coloured water.
5. Slowly pour water in the first beaker until it reaches the top of the gravel. Record exactly how much water was poured into the beaker. (If you need more than 100 ml of water, fill the graduated cylinder again.)
6. Follow step three for the other two beakers.
7. Calculate the porosity of the three materials using this formula:

$$\text{Porosity} = \frac{\text{volume of water}}{\text{volume of material}} \times 100$$

8. Fill in the results table on the next page, answer the questions about your results and the assessment questions.

Answers for Assessment Questions:

1. What do the words porosity and permeability mean?

   Answer: The porosity of a rock is a measure of its ability to hold a fluid.
   The permeability refers to the ability of liquids and asses to move though pore spaces in rocks.

2. Why is porosity (pore space) in rock layers important to oil and natural gas accumulation?

   Answer: D (Both B and C) - It allows oil and natural gas to migrate and it allows oil and natural gas to collect in reservoir rock.

3. Geologists look for oil and natural gas deposits in what type of rock?
   Answer: Sedimentary rock

Extension Ideas:

- How long have people been looking offshore for oil?

  In the late 1800's the citizens of Summerland, California, began producing the numerous springs of crude oil and natural gas that dotted their landscape. After drilling a large number of wells, these early oilmen noticed that those nearest the ocean were the best producers. Eventually, they drilled several wells on the beach itself. Have the students find Beaumont, Texas on a large map. Using the same method of reasoning as the residents of Summerland, California, in 1897, what conclusions might you draw about the presence of oil in the Gulf of Mexico? Have the students research Spindletop and share their findings.

Home Links

- Challenge pupils to test different materials to determine their porosity.

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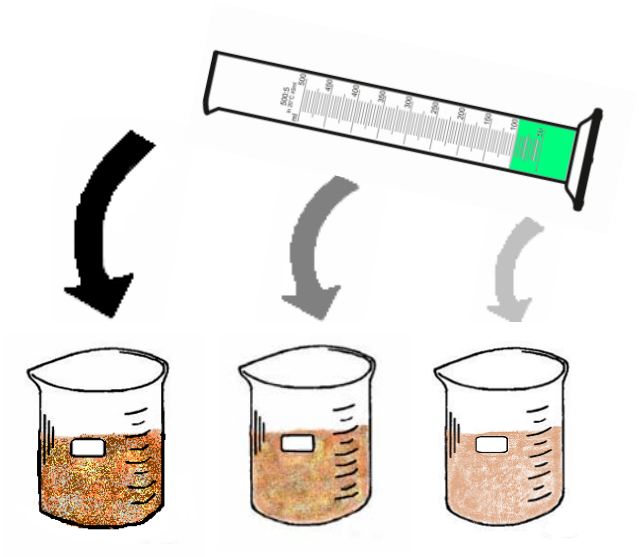
Experiment Record

Secondary Pupils

Materials

- 1 bag large gravel
- 1 bag small gravel
- 1 bag sand
- 1 100 ml measuring cylinder
- 3 500 ml beakers
- Water coloured with food dye



Instructions

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8. Fill in the results table on the next page, answer the questions about your results and the Assessment Questions.

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Experiment Record

Seconday Pupils

Results:

Type of Material	Volume (ml) of water poured	Volume (ml) of material	% Pore space in material
large gravel			
small gravel			
sand			

1. Which material held the most water?

2. Which material held the least water?

3. Draw a picture of what would happen if oil were poured into a bottle of large gravel that was already half full of water. Be sure to label the oil and water layers on your drawing.

4. Draw a bar graph comparing the percentage of pore space for each material.

Assessment Questions:

1. What do the words porosity and permeability mean?

2. Why is porosity (pore space) in rock layers important to oil and natural gas accumulation?
a. It prevents oil and natural gas from migrating to the surface.
b. It allows oil and natural gas to migrate.
c. It allows oil and natural gas to collect in reservoir rock.
d. Both B and C

3. Geologists look for oil and natural gas deposits in what type of rock?