

Topic

Reservoirs and Production

Source

Oil and Natural Gas, pages 24-25, 26-27

Objective

The students will learn that 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.

Lesson Preparations

1. Make copies of the lab packet, porosity data table and exit questionnaires for each student
2. Collect all materials
3. Read over "Explanation" section of lesson plan

Materials

Engagement

Marble cake

Clear plastic straws

Exploration

(If students are divided into groups, the following materials are needed for each group)

1 bag of large gravel

1 bag of small gravel

1 bag of sand

1—100 ml graduated cylinder

3—600 ml beakers

Water colored with food coloring

National Science Education Standards

NS.5-8.1

Science As Inquiry

Students should develop

- Abilities necessary to do science inquiry
- Understanding of science inquiry

NS.5-8.2

Physical Science

- Properties and changes in properties of matter
- Motions and Forces
- Transfer of Energy

NS.5-8.4

Earth and Space Science

- Structure of the earth system
- Earth's history
- Earth in the solar system

NS.5-8.5

Science and Technology

- Abilities of technological design
- Understanding about science and technology

NS.5-8.7

History and Nature of Science

- Science as a human endeavor
- Nature of science
- History of science

Math topics on volume and measurement are also included.

Engagement

Purchase or bake a marble cake. Make sure the dark layer cannot be seen from the surface of the cake or frost the cake so the colors of the layers cannot be seen. Using a clear plastic straw, take a core sample from the cake. Ask students to make predictions of what the cake looks like inside? What kind of cake might this be? Explain to students that you just took a core sample out of the cake. Tell students that today we are going to learn how geologists look at core samples of the earth and determine the porosity of the rock that is beneath the surface and the permeability.

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 amount 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!

Exploration

Teacher Directed

1. Fill one beaker to the 350 ml mark with large gravel. Fill another beaker to the 350 ml mark with small gravel. Fill a third beaker with 350 ml of sand.
2. Fill the graduated cylinder with 100 ml of water.
3. 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.)
4. Follow step three for the other two beakers.
5. Calculate the porosity of the three materials using this formula:

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

Explanation

Teacher Information

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

Oil and natural gas form 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 pore 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.

Read to students from *Oil and Natural Gas*, page 24

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.

Read to students from *Oil and Natural Gas*, page 26

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 economical, 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.

Evaluation

Students should complete the Exit Questionnaire.

Elaboration

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.

Exit Questionnaire Answer Key

1. What does the word porosity mean?

Answer: The porosity of a rock is a measure of its ability to hold a fluid.

2. Oil and natural gas are formed within the pores of rock. This type of rock is called:

Answer: D. Source rock

3. 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.

4. Geologists look for oil and natural gas in:

Answer: C. Sedimentary rock basins



Reservoirs and Production Lab Packet



Porosity Data Table

Type of Material	Volume (ml) of water poured	Volume (ml) of material	% pore space in material
Large Gravel			
Small Gravel			
Sand			

$$\text{Pore Space} = \frac{\text{Volume (ml) water poured into bottle}}{\text{Volume (ml) of substances in bottle}} \times 100$$

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.

Name: _____

Questions

1. What does the word porosity mean?

2. Oil and natural gas are formed within the pores of rock. This type of rock is called:

- a. Trap rock
- b. Reservoir rock
- c. Cap rock
- d. Source rock

3. 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

4. Geologists look for oil and natural gas in:

- a. Igneous rock basins
- b. Metamorphic rock basins
- c. Sedimentary rock basins
- d. Volcanic rock basins