Title: Oil and Natural Gas in Arkansas – Lesson 3: Deposits

Course(s): Science, Math, Library Media **Grades:** 5-8	**Duration**: 4 Class Periods (4 hours)

Arkansas Standards:

Subject	Grade Level(s)	Code	Standard
Science	5	5-PS1-3	Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [Assessment Boundary: Assessment does not include density or distinguishing mass from weight.]
	7	7-PS1-2	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [AR Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrochloric acid.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]
		7-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current

			geoscience processes. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]
Math	5	AR.Math.Content.5.OA.A.1	Use grouping symbols including parentheses, brackets, or braces in numerical expressions, and evaluate expressions with these symbols.
		AR.Math.Content.5.NBT.B.7	Perform basic operations on decimals to the hundredths place.
		AR.Math.Content.5.G.A.2	• Represent real world and mathematical problems by graphing points in the first quadrant and on the non-negative x- and y-axes of the coordinate plane. • Interpret coordinate values of points in the context of the situation.
Library Media	5-8	IL.1.5.7 IL.1.6.7 IL.1.7.7 IL.1.8.7	Select and interpret various types of information on a topic using a variety of print/non-print/digital resources (e.g., atlases, audiobooks, books, databases, dictionaries, eBooks, encyclopedias, globes, maps, videos, websites, periodicals, thesauri, almanacs, photographs, charts, graphs, diagrams, timelines, animations, interactive elements, primary sources, secondary sources, paintings)
Instructional Strategies and Practices:			

Cooperative Learning, Generating and Testing Hypothesis, Brainstorming and Discussion, Drawing, Labs
Blooms Level: Analyzing, Applying, Understanding, Remembering
Materials and Resources: Specific Materials are listed for each Activity/Lab in the Lesson.
Formative Assessment: Comprehension and Interpretation, Analysis Questions accompany/ follow each Activity/Lab.

Teaching Notes:
To form deposits of oil and natural gas four criteria must be met—1) source, 2) reservoir, 3) trap, and 4) seal. Source refers to the organic-rich rock that the oil/natural gas formed in. A reservoir is a porous/permeable rock that the oil/natural gas migrated into. The trap is what captures the oil/natural gas in the reservoir. And the seal is a nonporous/impermeable rock that keeps the oil/natural gas from leaking out. If any one of these criteria is missing, there can be no deposit. Understanding how these four criteria work together there are some concepts that need investigating. First is the physical property of matter called density. Density is best defined as the measure of how close together the atoms are in a substance. Density differences between rock, water, oil, and natural gas is one of the controls over the interaction of these materials within the Earth's crust. A second physical property is one that applies to fluids and is called viscosity. Viscosity is a measure of how easily a liquid flows. Porosity is another important factor. Porosity is a physical characteristic of rocks and is a measure of the amount of open space or "pores" in a rock. Pores are where the oil and natural gas "hang out" within the rocks. Finally, there is permeability. Permeability also refers to rocks, and is a measure of how connected the pores are in a rock. Connected pores mean that any fluid within the rock has the ability to flow. Disconnected pores mean that any fluid in the rock is trapped. Porosity and permeability are independent of one another, so this sets up a myriad of combinations that can exist for rocks. Some combinations are conducive to forming oil and natural gas deposits, some are not.

Student Activities:
- Student Handout 1 Lab 1—Understanding Density
- Student Handout 2 Lab 2—Understanding Viscosity
- Student Handout 3 Activity 1—Demonstrating Porosity in Rocks
- Student Handout 4 Lab 3—Investigating Porosity
- Student Handout 5 Lab 4—Investigating Permeability

Pre-assessment Question:
1. Define the following terms: density, viscosity, porosity, and permeability.

Background Information:
The following websites will provide background material for helping to understand density, viscosity, permeability, and porosity. These web sites may change over time. If a web site is no longer available, use the key words and phrases to find more current resources.

An interactive simulation of density
http://phet.colorado.edu/en/simulation/density

An introduction to viscosity
https://www.youtube.com/watch?v=1AESWxko4nI
https://www.britannica.com/science/viscosity
http://www.science-sparks.com/2012/04/23/viscosity-races-investigating-the-flow-of-liquids/

Easy Kids Science Experiments Density Tower (Video)
http://www.youtube.com/watch?v=9IcWwUH-Wj4

An animation comparing the permeability of different size materials
http://techalive.mtu.edu/meec/module06/Permeability.htm

Student Handouts: Student Handouts: See web site for a printable copy:
ttp://www.arkansasenergyrocks.com/educators/lesson-plans-k-8/

Student Handout 1

Lesson 3 – Oil and Natural Gas: Deposits
Lab 1 – Understanding Density

Introduction

If you throw a piece of wood into a lake what does it do? Why? In this lab you will be introduced to the concept of density and how it influences the interaction between substances. Density can be simply defined as a measure of how close together the atoms are in a substance and is a physical property of all matter. Density differences between rock, water, oil, and natural gas are a major control over the movement of these materials in the Earth's crust and are an important factor in creating oil and natural gas deposits. Look at the picture on the right. How can these different colored liquids exist as separate layers? That is what you will investigate in this lab.

Materials

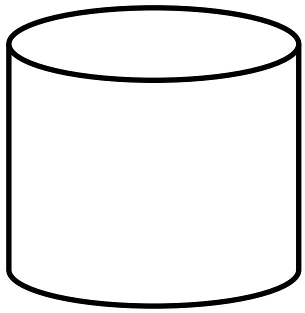
- Glass jar with lid or empty water bottle with lid
- 2-3 oz. plastic cups
- Vegetable oil
- Water

Procedure

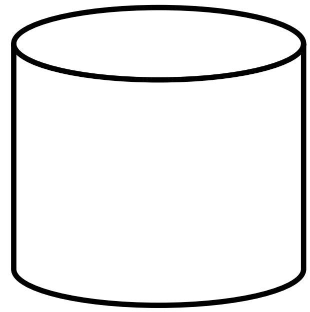
1. Use one of the plastic cups and pour 6 oz. of vegetable oil into the jar.
2. Use the other plastic cup and pour 6 oz. of water into the jar.
3. Observe what happens to the water.
4. Make a drawing of the contents in the jar in the results section.
5. Put the lid securely on the jar and shake it for about 10 seconds.
6. Place the jar on the desk in front of you and observe what happens to the liquids.
7. After it sits for a minute, make another drawing of the contents in the jar.

Results

Make two drawings of the jar and label the layers.



Before Shaking



After Shaking

Analysis and Conclusions

1. What was in the jar before you poured in the liquids?

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2. What happened to the oil when you poured in the water? Why?

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3. How many layers are in the jar?

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4. What happened to the liquids in the jar when you shook it and allowed it to sit? Why?

5. There is an expression that states “Oil and water don’t mix.” Is this true? Why?

Student Handout 2

Lesson 3 – Oil and Natural Gas: Deposits
Lab 2 – Understanding Viscosity

Introduction

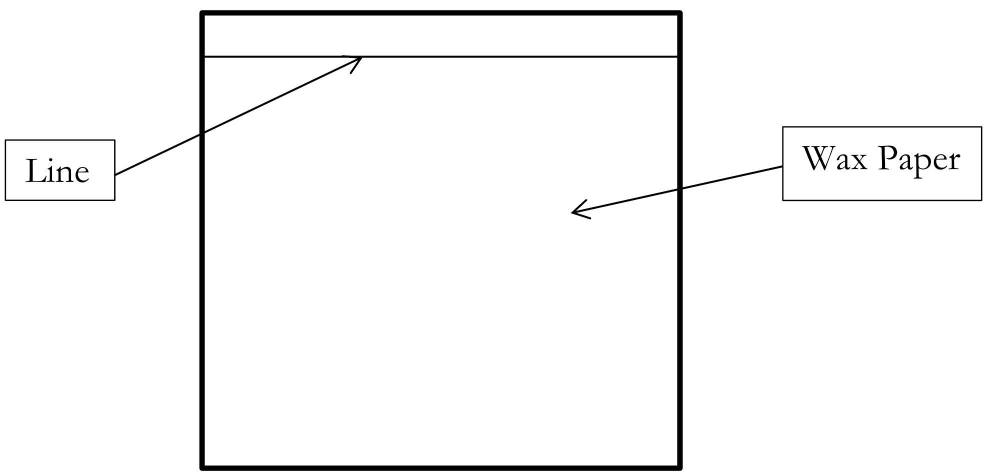
In this simple experiment you will explore the meaning of viscosity and its importance as a physical property of fluids.

Materials

- Ruler
- Paper towel
- Wax paper
- Timer
- Permanent marker
- Three 3 oz. paper cups (1 for each liquid)
- Plastic spoon
- Vegetable oil
- Syrup
- Honey

Procedure

1. Cut a sheet of wax paper about 30 centimeters long
2. Use the maker to draw a line across the wax paper about 3 cm from one edge. See diagram below.



3. Place the paper towel on your desk. This is to catch the liquids.
4. Place the wax paper on the paper towel.
5. Pour about a spoonful of the oil on the line you drew on the wax paper.
6. Quickly raise the edge of the wax paper until vertical and time how long it takes for the oil to reach the opposite edge of the wax paper.
7. Record the time in the data table.
8. Repeat steps 4 through 7 for the other two liquids.

Results

Liquid	Time
Oil	
Honey	
Syrup	

Analysis and Conclusions

1. Plot a graph of the data collected in your experiment.

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2. Since all three materials are liquids, why do they not all flow at the same speed?

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3. Rank the liquids in order of decreasing speed.

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4. Which liquid has the lowest viscosity? The highest viscosity?

5. If you were to include water in your ranking of liquids, where would it be?

6. Explain how the viscosity of oil might affect how easily it can be pumped from the ground.

7. Oil deposits are often associated with salt water and natural gas. What would be the correct sequence of these materials from top to bottom?

Student Handout 3

Lesson 3 – Oil and Natural Gas: Deposits
Activity 1 – Demonstrating Porosity in Rocks

Introduction

Oil and natural gas deposits occur in the sedimentary rocks in the Earth's crust. How is it possible for a liquid or gas to be "in" a rock? The answer lies in the picture on the right. This is a close up picture of a sponge. Notice that the sponge has a lot of holes in it—these are called "pores". Some of the rocks in the Earth's crust also contain pores. Sometimes the pores can be easily seen, but usually they are tiny and can only be seen with a microscope. Oil and natural gas can be stored in these pores.

Materials

- 1 sample each of sandstone, shale, limestone, and chert
- Magnifying glass
- Eye dropper
- Water

Procedure

1. Write a brief description of each rock, use the magnifying glass to help you notice small details.
2. With your fingers observe the surface texture of each rock and record in the results section what you determined.
3. Now use the eye dropper to place a drop of water on each of the rock samples.
4. Describe for each rock if the water sits on the surface of the rock or soaks into the rock.

Results

Rock	Description
Sandstone	
Shale	
Limestone	
Chert	

Rock	Surface Texture		Behavior of Water Drop	
	Rough	Smooth	Sits on Top	Soaks In
Sandstone				
Shale				
Limestone				
Chert				

Analysis and Conclusions

1. Which rocks “allowed” the water to soak into them? Why?

2. What was the relationship between surface texture of the rock and the behavior of the drop of water? Why?

3. Which rocks would be good oil and gas reservoirs? Why?

Student Handout 4

Lesson 3 – Oil and Natural Gas: Deposits
Lab 3 – Demonstrating Porosity

Introduction

In the previous lab you observed that certain kinds of rocks have open spaces in them called pores. Even though these pores are often microscopic, they still allow fluids to soak in (See photograph to the right). A measure of volume of the pores is called porosity. In this lab you will investigate how the volume of the pores, or porosity, controls the volume of liquid that a material can store.

Materials

- 2-500 ml beakers
- 1-100 ml graduated cylinder
- Aquarium gravel (small gravel)
- Medium sized gravel (available from craft stores)
- Water

Procedure

1. Fill one of the beakers with 200 ml of small gravel.
2. Fill the other beaker with 200 ml of the medium sized gravel.
3. Fill the graduated cylinder with 100 ml of water.
4. Slowly pour the water into the small gravel until it reaches the top of the gravel.
5. Record in the results section how much water you poured into the beaker.
6. Refill the graduated cylinder to 100 ml.
7. Slowly pour the water into the medium gravel until it reaches the top of the gravel.
8. Record in the results section how much water you poured into the beaker.

Results

Material	Volume Of Water Poured	Volume Of Gravel	Porosity In Percent
Small Gravel		200 ml	
Medium Gravel		200 ml	

Now you will calculate the porosity of each type of gravel using the following formula:

Porosity = (Volume of Water Poured ÷ Volume of Gravel) X 100

Analysis and Conclusions

1. Which size gravel has the greatest porosity?

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2. If you had a beaker of sand, would it have more or less porosity than the gravel?

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3. Why is porosity important for the formation of oil and natural gas deposits?

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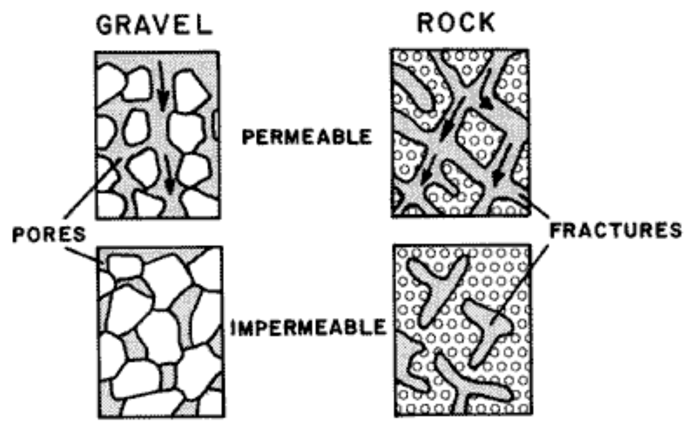
Student Handout 5

Lesson 3 – Oil and Natural Gas: Deposits
Lab 4 – Investigating Permeability

Introduction

In the previous lab you investigated a property of rocks called porosity. Permeability is a measure of how easily a liquid can flow through a material. That happens when the "pores" in a material are connected. Think of it as tunnels for liquid or gas to travel through. Look at the diagram to the right. You will test the permeability of two different materials: marbles and plastic pellets. Secondly, you will investigate the ability of different materials to hold on to some of the oil. This affects how much of the oil can actually be pumped out of the ground.



From: **http://pubs.usgs.gov/of/1993/ofr93-643/**

Materials:

- 3—100 ml graduated cylinders
- 2 funnels
- Timer
- Marbles
- Plastic pellets (used for flower vases)
- Ruler

Procedure:

1. Measure the diameter of one of the marbles and describe its shape and texture. Record this information in the data table in the results section.
2. Fill one of the funnels with marbles so that it is even with the top.
3. Place the funnel with marbles on top of one of the graduated cylinders.
4. Fill the other funnel with plastic pellets so that it is even with the top.
5. Place the funnel with plastic pellets on top of one of the graduated cylinders.
6. Fill the third graduated cylinder with 50 ml of water.
7. Pour the water into the marbles **slowly and evenly,** start the timer as soon as you start pouring.
8. Time how long it takes for the water to drain through the marbles. Stop timing when the water quits dripping.
9. Record the time in the data table.
10. Look at the volume of water in the graduated cylinder, this is the volume of infiltrated water; record this in the data table.
11. To find the amount of stored water, subtract the infiltrated water from the original water volume. Record this in the data table.
12. Repeat steps 6-11 with the plastic pellets.

Results:

Description of materials:

Material	Size	Shape	Texture
Marbles			
Plastic Pellets			

Time Data:

Material	Time
Marbles	
Plastic Pellets	

Volume Data:

Material	Starting Water Volume	Volume of Infiltrated Water	Volume of Stored Water
Marbles	50 ml		
Plastic Pellets	50 ml		

Analysis and Conclusions:

1. Make a graph of the time it took for the water to travel through the materials.

   Title ______________________________

2. Which material has the greatest permeability? The least? Why?

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3. Make a graph of the stored water volume for the materials.

4. Which physical characteristic of the materials do you think has the greatest influence on permeability?

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5. Which of the materials holds on to the most water? ____

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