Life:Powered

# MAKING A SEDIMENTARY ROCK/ POROSITY & PERMIABILITY OF ROCK: A Lesson on Energy Resources for All Grades

# MAKING A SEDIMENTARY ROCK/ POROSITY & PERMIABILITY OF ROCK: A Lesson on Energy Resources for All Grades

## EXPLORE: Making a Sedimentary Rock & Porosity and Permeability of Rock

**(See worksheets: *Making a Sedimentary Rock* and *Porosity and Permeability of Rock*)**

The fossil fuels that are so abundant in the United States are found and stored in sedimentary rocks, which are formed from bits and pieces of other rocks. They may include sand, clay, pebbles, seashells, and pieces of organic matter such as leaves. These bits and pieces settle out of water or are deposited by wind and build up in thick layers so that the lower layers are under great pressure. Then minerals in water flowing through the buried sediments crystalize and bond the pieces into solid rock. The rock layers which form deep in the earth may then be uplifted and exposed at the surface. Fossils of animals such as phytosaurs, amphibians, fish, saber-toothed cats, rhinoceroses, and tortoises are found in different layers. The type of animal fossils found in a rock formation tells us something about the environment when the sediments were deposited.

Lab Activity 1, Making a Sedimentary Rock, has students model lithification, one way sedimentary rocks are formed. After the “rocks” have dried, guide students in observing their rocks. Ask questions such as: Can you see the salt? How does it hold the pieces together? Are there spaces between the particles? What would represent fossils?

Give students some common materials such as a kitchen sponge, a block of Styrofoam, a block of wood, etc., and a cup of water and a dropper (or a dropper bottle). Do not tell them what to do; ask them what they are going to do. They should conclude that they can put a drop of water on the different materials and see what happens to each. Is the water absorbed, or does it just sit on top of the object? Encourage students to observe the objects closely and try to figure out why the water does what it does.

Ask them guiding questions and encourage them to talk with each other to try to figure out what to do and why the water responds differently on different objects.

Then introduce Lab Activity 2, Porosity and Permeability of Rock. Have students predict what each of the samples they are given will do when water is added to them.

**Notes:**

Be sure to use gym chalk (magnesium carbonate) and not chalkboard chalk (calcium carbonate) for this activity. The chalkboard chalk dissolves too easily. You can order the gym chalk online or perhaps borrow some from the gymnastics team if your school has one.

Rock samples need to be small enough to fit into the graduated cylinder in order to find their volume. You may need to break them up if they are too Large. It is okay to use several small pieces rather than one larger piece.

The water displacement method can be used to find the volume of the rock (an irregular solid). Water's density is 1g/mL, so 1 gram of water has a volume of 1cm3 or 1mL. For water: 1g = 1cm3 = 1mL

Other types of rock can be used, e.g., scoria or basalt. Just be sure to include sandstone and shale so that the relationship to drilling for oil is clear.

This activity is modified from the Rock Porosity Experiment developed by Tori Hellmann, UCAR AirWaterGas Teacher-in-Residence and found online at AirWaterGas NSF Sustainability Research Network.

# EXPLORE: Making a Sedimentary Rock Worksheet

## Introduction

Sedimentary rocks are formed from bits and pieces of other rocks and may include sand, clay, pebbles, seashells, and pieces of organic matter such as leaves. These bits and pieces settle out of water or are deposited by wind and build up in thick layers. Then minerals in water flowing through the buried sediments crystalize and bond the pieces into solid rock. The rock layers may then be uplifted and exposed at the surface. The rock layers exposed in the canyon Include sandstone, shale, siltstone, and conglomerate. Fossils of animals such as phytosaurs, amphibians, fish, saber-toothed cats, rhinoceroses, and tortoises are found in different layers. The type of animal fossils found in a rock formation tells us something about the environment when the sediments were deposited.

### Materials

- Bowl or container for mixing materials
- Sand, silt, clay, small gravel, and a few crushed shells
- Pieces of crushed dry leaves
- Epsom salt
- 250mL beaker
- Spoon
- Small paper cup
- Water
- Hand lens
- Rock samples such as sandstone and shale

### Procedure

1. Measure 50mL of Epsom salt in the dry beaker and pour into the mixing bowl.
2. Measure 100mL of water in the beaker and pour into the mixing bowl.
3. Stir until most of the salt is dissolved.
4. In the paper cup, place about 3-4 cm of the mixture ingredients and mix thoroughly. Add enough of the salt solution to just cover the sand mixture. Mix well.
5. Let the mixture stand until dry (2-3 days).
6. After the mixture is dry, cut off the paper cup.
7. Observe the “rock” closely. Can you see the salt? How does it hold the sand together? How does the rock you created compare to the actual rock samples?

# EXPLORE: Porosity and Permeability of Rock Worksheet

## Introduction

Oil, gas, and water may be held in and/or move through rocks. How is this possible? In this lab activity, we will examine porosity and permeability of different types of rocks.

### Materials

- Kitchen sponge
- Block of Styrofoam
- Block of wood
- Cup of water
- Dropper or dropper bottle

### Procedure

1. Put drops of water on various materials. Why does water respond differently?
2. Sedimentary rocks are able to hold fluids (liquids and gases) because of the physical properties of porosity and permeability. Porosity is the term used to describe how much pore space (space between the grains) is in the rock. Permeability refers to the ability of the fluids to move through the rock. Therefore, porosity describes the ability of the rock to hold a fluid and permeability is the measure of how easily the fluid can flow through the rock.
3. In drilling for oil and gas, conventional drilling extracts oil and gas that flow easily through rock and collect in areas where they can easily be brought to the surface by drilling vertical wells. Unconventional drilling method including horizontal wells and hydraulic fracturing (fracking), involve pumping a mixture of water, sand, and chemicals into the well at high pressure in order to create fissures in the shale rock, which increases permeability and allows he hydrocarbons to escape.

*In the next experiment, we will demonstrate how different types of rock absorb water and relate this to where oil and gas are found.*

## Materials (per group)

- Small pieces of gym chalk (magnesium carbonate*)*
- marble, pumice, granite, sandstone, and shale.
- 6 small clear plastic cups (8 oz. size)
- Graduated cylinder (250 mL if available)
- Electronic balance (or triple-beam if electronic is not available)
- Water
- Paper towels
- Plastic wrap
- Graph paper

*Note: Be sure to use gym chalk, NOT chalkboard chalk.

## Problem

Which of the rock types hold the most water after being soaked for several days? How does this relate to the porosity of the rocks?

Prediction:

_____

# EXPLORE: Porosity and Permeability of Rock Worksheet cont'd

**Procedure**

1. Find the mass of each rock sample and record in the data table.
2. Determine the volume of each rock sample using water displacement and record.
3. Label each plastic cup with the type of rock, then place 200mL of water in each cup.
4. Place each rock sample in its designated cup and leave it submerged for 10 minutes.
5. After 10 minutes, remove each sample from its cup and dry off excess water with paper towels, find the mass of each and record. Replace the sample in its cup.
6. Repeat every 10 minutes for the rest of the class period.
7. After the last measurement, cover each cup with plastic wrap.
8. After 1 day, dry each sample, find its mass and record. Return samples to cups and cover.
9. Repeat step 8 twice more.
10. After the 72-hour measurement, clean up your materials and complete Data Table 1.

## DATA TABLE

| ROCK TYPE | VOLUME OF ROCK (mL) | INITIAL MASS (g) | Mass after ... | | | | | | | OVERALL CHANGE IN MASS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10 min. | 20 min. | 30 min. | 40 min. | 24 hrs. | 48 hrs. | 72 hrs. | |
| Marble | | | | | | | | | | |
| Chalk | | | | | | | | | | |
| Pumice | | | | | | | | | | |
| Sandstone | | | | | | | | | | |
| Shale | | | | | | | | | | |
| Granite | | | | | | | | | | |

**11.** Complete Data Table 2, graph your results and answer the conclusion questions.

**Calculations**

To find the porosity of each rock sample, compare the change in the mass of the rock sample to the volume of the rock sample. The change in mass relates to the volume of water absorbed by the rock, because for water, 1g = 1cm3 = 1mL.

Use the following formula:

Overall change in mass = Volume of water absorbed

Volume of water absorbed ÷ Volume of rock sample x 100 = Percent Porosity

Example: Water absorbed was 7mL, and the volume of the rock sample was 35mL. 7mL ÷ 35 mL x 100 = 20%

# EXPLORE: Porosity and Permeability of Rock Worksheet cont'd

## DATA

| ROCK TYPE | TOTAL VOLUME OF WATER ABSORBED | VOLUME OF ROCK (FROM TABLE 1) | PERCENT POROSITY |
|---|---|---|---|
| Marble | | | |
| Chalk | | | |
| Pumice | | | |
| Sandstone | | | |
| Shale | | | |
| Granite | | | |

**Conclusions**

1)Which rock had the highest percent porosity? _____

2)Which type of rock has the potential to hold the most water, oil, or gas? Explain why.

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3)If you were looking for a rock formation to hydraulically fracture to find oil or gas, which type of rock formation would you choose and why? Choose from granite, shale, or sandstone. (Hint: think about how porous each of these rocks is and how each was formed.)

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4) When a well is drilled and fracked, it often goes down through many layers of rock, including sandstone, shale, and limestone, before reaching the layer of shale that contains oil and gas. Concrete is poured down around the outside of the well, forming a casing all the way down. Why is this important? (Think about the porosity of the different kinds of rock.)

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These activities are modified from the Rock Porosity Experiment developed by Tori Hellmann, UCAR AirWaterGas Teacher-in-Residence, and located at AirWaterGas NSF Sustainability Research Network, https://www.airwatergas.org/resources/curriculum/rock-porosity-experiment/.

(1) Sedimentary Rock, an activity from Rockology 101 developed by the Rogers Group: http://www.rogersgroupincint.com/IndustryResources/Rockology101Activities/ActivitySedimentaryRock/ tabid/105/Default.aspx.; (2) https://www.airwatergas.org/resources/ curriculum/rock-porosity-experiment/.