Rock Porosity Experiment

Students will investigate the porosity and permeability of rock formations that may hold oil, gas, and water.

CREDITS: Lesson developed by Tori Hellmann, UCAR AirWaterGas Teacher-in-Residence with support from science advisor Jessica Rogers.[1] This version was made possible by collaboration between Inside Energy and AirWaterGas, a Sustainability Research Network funded by the National Science Foundation.

GRADE LEVEL: 6-10

LESSON FORMAT (CONTENT): Hands-on activity

TIME REQUIRED:
Teacher Prep Time: Approximately 15-20 minutes
Class time: One ~90 minute block period

LEARNING GOAL: Students will be able to relate the physical properties of permeability and porosity of rock formations to the amount of water, oil, and natural gas held in these formations.

MULTIMEDIA RESOURCES
This activity can be paired with the Inside Energy video, "Why Fracking, And Why Now?", to aid in comprehension and provide additional discussion points. The video can be used before the activity as an introduction or after the activity to promote sense-making.

MATERIALS (FOR EACH LAB GROUP):
A marble, small pieces of chalk (magnesium carbonate)[2], pumice, granite, sandstone and shale

- 250mL beaker for each rock sample (6 total)
- Graduated cylinder
- Electronic balance
- Water
- Raw Data Table
- Processed Data Table

[1] https://www.airwatergas.org/resources/curriculum/rock-porosity-experiment/

[2] *Note: be sure to use **gymnast chalk,** magnesium carbonate, not chalkboard chalk for this activity.

STANDARDS

Next Generation Science Standards

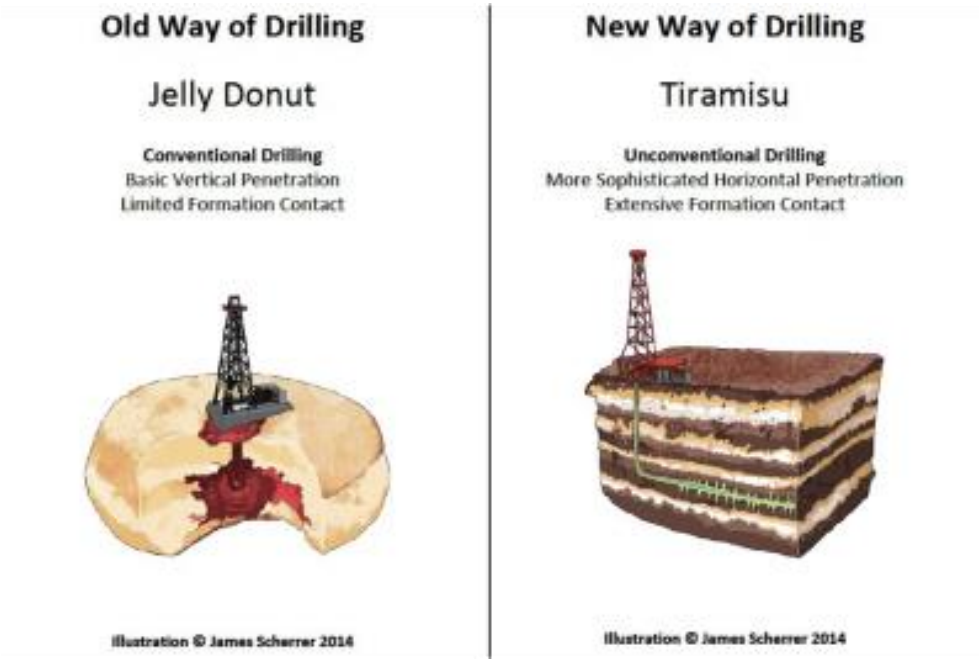
- *HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. ESS3.A*

Colorado Academic Standards - Science

- *SC09-GR.HS-S.3-GLE.5 There are costs, benefits, and consequences of exploration, development, and consumption of renewable and nonrenewable resources.*
- *SC09-GR.6-S.3-GLE.2 . Water on Earth is distributed and circulated through oceans, glaciers, rivers, ground water, and the atmosphere.*
- *SC09-GR.6-S.3-GLE.3 Earth's natural resources provide the foundation for human society's physical needs. Many natural resources are nonrenewable on human timescales, while others can be renewed or recycled.*

INTRODUCTION

Oil and gas are held underground in sedimentary rock formations and can be extracted through many different methods. Conventional drilling extracts “easy to reach” oil and gas, which flows to the surface through a vertical well. Unconventional drilling techniques, or drilling horizontal wells and the process of hydraulic fracturing, are used to extract trapped oil and gas from geological formations. See the illustration below that compares drilling techniques to desserts.



Sedimentary rocks have the ability to hold oil, natural gas, and water due to physical properties called porosity and permeability. Porosity refers to the tiny air spaces in the rock itself. Permeability is a measure of the ability a rock to allow water, oil, natural gas, or other fluids to pass through it. In other words porosity is the rock’s ability to hold a fluid and permeability is the rock’s allowance or resistance to flow of a fluid through it.

EXPERIMENT

Purpose: Demonstrate how different types of rock absorb water and how this relates to where we find oil and gas.

Problem: Which type of rock will hold the most water after being submerged in water for several days? How does this relate to the rock’s porosity?

Hypothesis: Ask students to write an “If, then” statement relating back to the problem.

Procedure

- Weigh each sample and record the weight in the Raw Data Table provided.
- Find the volume of your rock sample using water displacement method.
- Record the volume of each sample in the Raw Data Table.
- Dry off each sample after finding the volume.
- Fill the 250mL beaker with 200mL of water.

- Place each sample in beaker and leave it submerged in the water for 10 minutes.
- After 10 minutes remove the rock sample, shake or dab off any excess water, and weigh and record the weight in the data table.
- Place the sample back in beaker and repeat every 10 minutes for the remainder of the class period.
- After the last measurement, cover each beaker with plastic wrap and leave them on counter.
- Take weight measurements again after a 24-hour period and record.
- Place the samples back on counter and repeat measurements daily for three days.

ANALYSIS

Once students have completed their Raw Data Table, ask them to complete the Processed Data Table. Ask students to graph their results.

CONCLUSION QUESTIONS

1. Which rock had the highest porosity (% of water absorbed)?
2. Which type of rock has the potential to hold the most water, gas or oil? Explain.
3. In which type of rock would you expect to find an aquifer? Why?
   If you were looking for a rock formation to hydraulically fracture for oil and gas, which formation would you choose and why? Choose between granite, sandstone, or shale.
4. What would be the costs and benefits of drilling for oil or water in sandstone versus shale?
5. Explain the importance of the cement casing used during fracking and relate this to porosity.

CONCLUSION

Ask students to revisit their hypothesis, discuss their results, address the strengths and weaknesses of the experiment, and list two suggestions for further experiments or research.

TEACHER NOTES

Do not use chalkboard chalk for this experiment, it dissolves too quickly. Magnesium carbonate is gym chalk and can be purchased at sports supply stores (or if you have a gymnastics team, maybe you can borrow some from them). A 1lb box will be adequate for several experiments.

Pieces of sample rock need to be small enough to fit into a large (500mL) graduated cylinder. You may need a hammer to break samples into small enough pieces or use samples from a rock sample kit. You can use other types of rock samples such as scoria or basalt. Just be sure to use a piece of shale and sandstone to represent the actual rock formations associated with oil and gas drilling.

EXTENSION

Repeat this experiment with oil, remembering that oil is less dense than water and so will occupy more space than the water.