RESOURCE LIBRARY
ACTIVITY : 45 MINS

Extracting Gas from Shale

Students discover how geologists use the composition and location of rocks to find deposits of oil and natural gas. They use an interactive computational model to explore how hydraulic fracturing releases natural gas from deep shale formations.

GRADES

7 - 12+

SUBJECTS

Earth Science

CONTENTS

2 Images, 3 Links

OVERVIEW

Students discover how geologists use the composition and location of rocks to find deposits of oil and natural gas. They use an interactive computational model to explore how hydraulic fracturing releases natural gas from deep shale formations.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/extracting-gas-shale/

Content Created by

The Concord Consortium

DIRECTIONS

1. **Activate students' prior knowledge about natural gas.**

Tell students the United States has produced natural gas commercially for over 100 years. Show the **Natural Gas Gross Withdrawals and Production Graph.** (In media carousel; click the download arrow lower right.) Ask:

- *How has the production of natural gas changed since 1950?* (Production of natural gas has increased since 1950.)

- *From where has the most recent increase in natural gas come?* (The most recent increase in natural gas production has come from shale gas resources. See the yellow line on the graph.)

Share with students that recent technologies have made it possible to extract natural gas from deep underground shale formations. Let students know they will be using models to explore how natural gas is released from shale.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the idea that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Show the **Geologic Cross-Section of Ohio and Pennsylvania**. Tell students the Marcellus Shale contains natural gas. They can see examples of scientists' uncertainty in knowing how deep or how thick the shale layers are in some areas. Ask your students to think about these questions, based on the cross-section of Marcellus Shale.

- *Is it possible to drill at the same depth to reach the Marcellus Shale?* (No. The Marcellus Shale is buried at different depths, depending on the location. The Marcellus is deeper in Pennsylvania than it is in Ohio.)

- *How do you think scientists know where to drill to reach the shale layer?* (Student answers will vary. One way to know where to drill is to drill many different test wells to figure out the shape of the underlying shale layer.)

Tell students they will be asked questions about the certainty of their predictions and to think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model they may have seen, such as forecasting the weather. The **NOAA Weather Forecast Model** provides a good example. Reinforce the fact that scientists use models to predict the locations and quantity of natural gas deposits. Tell students that:

- geophysicists use physical characteristics, such as magnetic and gravitational properties, to guess the type and shape of subsurface rocks.
- scientists use technologies to model and visualize layers below the surface that they cannot see.
- scientists test their models by drilling and sampling.

4. Have students launch the Extracting Gas from Shale interactive.

Provide students with the link to the Extracting Gas from Shale interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer work stations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Let students know that this is Activity 3 of the **What Are Our Energy Choices?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How does natural-gas filled shale form?* (In deep oceans, organic material falls to the bottom and is compressed by the weight of the water and other sediments on top of it. Eventually, the organic material starts to decay into oil and natural gas. This happens at great pressures and temperatures, which come about as the rock is buried deeper and deeper underground.)

For the next questions, show **Model 1: Hydraulic Fracturing**.

- *Why doesn't shale release its natural gas without being fractured?* (Natural gas doesn't flow easily out of the shale because it is not very permeable. The fracturing process increases the permeability of the shale so natural gas can flow out.)

- *What happens to the water that is used during the hydraulic fracturing process?* (Water is pumped underground to fracture the shale. Then some of it returns to the surface, where it is stored in pools above ground.)

- *Can you predict the shape of a shale formation from a single point?* (It is not possible to predict the shape of a shale formation with just a single point. The shale formation may be inclined or declined from a single point, or it may be thicker or thinner. It is possible for the shale formation to be discontinuous if there was an isolated geologic uplift.)

- *Why does the natural gas output of a well decline over time?* (The natural gas output declines over time because the gas that was in the shale is removed. It takes more time to generate more natural gas than it does to remove it from the shale.)

TipTeacher Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the What Are Our Energy Choices? lesson. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How is shale formed?
- Why does some shale contain oil and/or natural gas while other shales do not?
- Why does shale have to be fractured to release the trapped natural gas?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- describe how oil and natural gas are formed
- describe how geologists find the shales with oil and/or natural gas resources
- explain why shale needs to be fractured to release natural gas

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning

- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard F-1:**
Personal health
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard F-1:**
Personal and community health

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:
Research and Information Fluency

• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1**:
Patterns

• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction

• **Crosscutting Concept 3**:
Scale, proportion, and quantity

• **Crosscutting Concept 4**:
Systems and system models

• **Crosscutting Concept 5**:
Energy and matter: Flows, cycles, and conservation

• **Crosscutting Concept 6:**
Structure and function
• **Crosscutting Concept 7:**
Stability and change
• **HS. Earth and Human Activity:**
HS-ESS3-2. Evaluating competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
• **Science and Engineering Practice 1:**
Asking questions and defining problems
• **Science and Engineering Practice 2:**
Developing and using models
• **Science and Engineering Practice 4:**
Analyzing and interpreting data
• **Science and Engineering Practice 5:**
Using mathematics and computational thinking
• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

Preparation

What You'll Need

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per small group, Projector

PHYSICAL SPACE

- Classroom
- Computer lab
- Media Center/Library

GROUPING

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

BACKGROUND & VOCABULARY

Background Information

Geologists find oil and natural gas deposits by reading the history in the rocks. Oil and natural gas are formed when organic material is compacted and heated over long periods of time. Water and other sediments over the organic material can provide a lot of pressure to pack the layer. Under certain circumstances the layer can eventually produce oil and gas. Therefore, geologists look for specific rock types and geologic formations in areas that were once covered by large bodies of water such as ancient seas or lagoons.

Sedimentary rocks are formed when many layers of sediments are compacted together; most sedimentary rocks form under large bodies of water. Since Earth's continents are continually moving and areas that were once covered by water may no longer be covered by water, geologists look for sedimentary rocks with high organic matter content.

Shale is a tightly packed sedimentary rock. The shale is very porous, but it is not very permeable. This allows the shale to hold a lot of oil/natural gas but makes it difficult to remove those energy sources. Recent technologies have made it possible to extract the oil and natural gas trapped in deep shale formations.

Hydraulic fracturing increases the permeability of the shale by forcing open the natural cracks in the shale. Water or other fluids, such as propane, are pumped into wells, cracking open the natural fissures in the rock. The fractures are kept open by use of proppants, such as sand.

Prior Knowledge

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Recommended Prior Activities

- Electricity: Sources and Challenges

Vocabulary

Term	Part of Speech	Definition
hydraulic fracturing	*noun*	process usually used to extract oil and natural gas in which rocks are fractured by injecting water, chemicals, and sand at high pressure. Also called fracking.
methane	*noun*	chemical compound that is the basic ingredient of natural gas.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
natural gas	*noun*	type of fossil fuel made up mostly of the gas methane.
permeable	*adjective*	allowing liquid and gases to pass through.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
shale	*noun*	type of sedimentary rock.

For Further Exploration

Articles & Profiles

- National Geographic Magazine: Bakken Shale Oil
- National Geographic: Daily News: Breaking Fuel From the Rock

Reference

- National Geographic Encyclopedic Entry: natural gas
- National Geographic Encyclopedic Entry: oil shale

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