# Finding Oil is a Piece of Cake

**Grade: 6-8**
**Time: 4 class periods**

## Lesson #B5:

## Where Does Energy Come From?

**Overview:**
Students simulate oil exploration by buying leases, developing plans, “drilling” a layer cake, and using samples to draw cross sections. They learn about unitization, calculate profits in a math activity.

**Essential Questions:**
- How do oil producers work together to share in the risks and benefits of exploration and extraction of oil?
- How can core samples help geologists to find oil?

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**Source:** Partially adapted from http://www.womeninmining.org/Layercake1.htm

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**Overview:**
Students simulate oil exploration by buying leases, developing plans, "drilling" a layer cake, and using samples to draw cross sections. They learn about unitization calculate profits in a math activity.

**Essential Questions:**

- How do oil producers work together to share in the risks and benefits of exploration and extraction of oil?
- How can core samples help geologists find oil?

**Assessment:**
Can students

- Use information from samples to make inferences about subsurface geologic conditions?
- Describe how unitization relates to efficiency, fairness, and environmental impacts of oil exploration?

**Vocabulary**

- Anomaly
- Porous
- Porosity
- Unitization
- Core Sample

## Alaska Standards Addressed:

### Science GLEs

The student demonstrates an understanding:
- the processes of science by [6, 7, 8] SA1.1 asking questions, predicting. Observing, describing, making generalizations, inferring, and communicating.

### Geography

A: 2) make maps, globes, and graphs;
A: 5) analyze how conflict and cooperation shape social, economic, and political use of space.
E 1) understand how resources have been developed and used; F: 3) analyze resource management practices to assess their impact on future environmental quality;

### Government and Citizenship

C: 1) understand the various forms of the state's local governments and the agencies and commissions that influence students' lives and property;
C: 7) understand the obligations that land and resource ownership place on the residents and government of the state E: 7) implement ways of solving problems and resolving conflict.
F7) implement ways of solving problems and resolving conflict.

**Math GLEs addressed:** The student demonstrates ability to use measurement techniques by [6] MEA-3 using a scaled ruler to an eighth of an inch or millimeter on a map or drawing [6] MEA-7 measuring length to the nearest 1/8 of an inch or nearest millimeter. The student accurately solves problems (including real-world situations) by [6] E&C-5 developing or interpreting scale models (scale factors such as 1 in. = 1 ft.) (L)[8] E&C-2 adding, subtracting, multiplying or dividing integers or positive rational numbers [8] E&C-3 using percents and percentages (e.g., tax, discount) [8] E&C-4 converting between equivalent fractions, decimals, or percents (M3.3.5) The student demonstrates an ability -to problem solve by [6][7][8] PS-1 selecting, modifying, and applying appropriate problem-solving strategies -apply mathematical skills and processes across the content strands by [6] PS-5 using real-world contexts such as social studies, friends, school and community [8] PS-5 using real-world contexts such as science, humanities, peers, community, and careers.

Teacher Information and Procedure

## *Prior knowledge for students:*

Some prior knowledge of geology would be helpful, but not absolutely necessary. Preceding (or following) this activity with the activity "Exploring New Technology" would help students to better understand the methods geologists use to find oil.

## *Materials needed:*

- Large rectangular cake pan, ingredients for cake. See Cake-Baking Instructions at the end of this lesson.
- 2 pkgs white cake Mix
- 1 pkg chocolate frosting
- 1 large rectangular foil baking pan
- Red food coloring to represent "oil"
- Blue, green, and/or yellow food coloring
- Colored pencils (black, blue, red, green and yellow)
- Graph paper
- Rulers
- 1-dozen clear plastic straws
- Single-sided razor blade.
- Paper plates, plastic forks, napkins
- Sharp knife

## *What to do in advance:*

- Bake an "oil field" cake. (*See cake baking ingredients*)
- Make a map of cake leases.
- Copy handouts.

## *What to do during the lesson:*

### *Gear up:*

Day 1

As a demonstration, fill three beakers to the same (measured) level with gravel, sand, and silt. Pour water into each beaker until it just reaches the top of the soil, using a graduated cylinder or measuring cup to determine exactly how much water it takes. Compare the amount of water held by each type of soil and discuss *porosity.* The amount of *pore space* is equal to the volume of water that the soil holds. Which type of soil is the most porous? Show how porosity is calculated. (Divide ml of water (pore space) by ml of soil and convert to a percent).

Ask students if they know how oil occurs underground. What are characteristics of an "oil reservoir"? Discuss the idea that oil is found in porous rocks. Discuss conditions besides porosity that are necessary for oil to occur. Why wouldn't oil be found in gravel (heat and temperature are needed to transform organic matter into oil, and under those conditions soil materials would be cemented and transformed into rocks)?

Show how a rock can be porous, using a piece of pumice that has been weighed, measured for volume (use a graduated cylinder and see how much water it displaces), immersed in water at least overnight. Tell students how much the rock weighed when it was dry, and then weigh it again. Since 1 ml of water weighs 1 gram, you will know how much water the rock absorbed. Calculate the rock's porosity.

More ideas:
-Use chalk instead of pumice, checking the weight every 5 minutes after immersing it until the weight stops increasing. Chalk will have greater porosity, but it will fall apart if left in water too long.
-Turn the demonstrations into student investigations and spend a day or two letting student groups do the measuring, weighing, observing, and calculating.
Complete lab instructions can be found at: http://www.planetseed.com/node/19768

Ask students if they know how geologists locate porous, oil-bearing rocks underground. Tell them that they'll be doing an activity that will help them learn about one method, core sampling, which is used to locate oil. They will also learn about how oil companies share in the costs and the profits that come from locating oil.

## *Explore:*

1) Present the cake* and explain that it represents a part of the North Slope that is suspected to be rich in oil reserves. Explain that the cake contains oil, represented by red cake, but its location under the frosting is unknown. Explain that some preliminary geologic studies have indicated that the greatest oil potential might be towards the northeast corner of the cake, but that there is also a small, rich deposit suspected somewhere in the southwest quarter. Show a map of the tracts of cake available for leasing.
*(if you want the cake to be fresher when it's time to eat it you may wish to just describe it today and bring it to class tomorrow!)

2) Read and discuss the background material on oil leasing and unitization as a class.

3) Divide students into 5 "oil companies" and select a couple of students to be state or federal officials. Explain the costs of drilling a well, and work through the "Do the Math" handout. Have students keep track of the money their company is spending as they complete the next steps.

Day 2

4) Conduct a "lease sale" by oral auction.

5) Form an "exploration unit" that contains all of the leases and, as a class, select the Unit Operator and come up with an exploration plan. Negotiate an agreement with the government that explains where you will drill and what precautions you will take to protect the surface of the cake. The agreement will allow 2-4 exploratory wells to be drilled. Draw the well locations on the lease map.

6) Give each student group graph paper, a ruler, and colored pencils. Decide on a unit of measurement for representing the drill cores.

7) Have members of the Unit Operator company drill the wells by gently pushing the straws into the cake. Examine the drill cores and measure each layer. Draw a representation of each drill core.

Draw a cross-section of the subsurface of the cake, predicting where the oil might be found.

Day 3

8) As a class, have oil companies and government officials work together to select boundaries for the "participating area". Make a development plan that outlines each company's share of the costs and the profits. It will also tell how many production wells will be drilled, where they will be drilled, where the processing facility will be located, and how you will protect and reclaim the environment.

7) "Drill" the production wells. Examine and measure each core sample and have students draw each one as it is drilled. Each core that has more than 2 mm of red cake is a producing well! Calculate your profits.

8) Draw a revised cross-section of the cake's subsurface.

9) Slice the cake and examine the location of oil, then eat it! .

## *Generalize:*

Day 4

Discuss the simulation: What does an oil company need to know before leasing and exploring for oil? Did all of your companies agree on where the boundaries should be set and how many wells should be drilled? Why do oil companies need to work together?

What are the risks and benefits associated with oil exploration?

Did you find "oil"? How many of your drill holes were useful in helping you to find the oil? Why would you want to have as much information as possible before beginning to drill?

Why is it complicated to find oil? What issues are involved in finding and developing oil fields?

## *Assess:*

Ask students to write responses to the following questions:

Why is core sampling useful to geologists exploring for oil, and why is it necessary to combine core sampling with other exploration methods?

Explain how "unitization" helps to make oil exploration and production more efficient, fair, and environmentally safe.

## *Extensions, adaptations, and more resources:*

For younger students, omit the interest problems on the "Do the Math" sheet.

Creative cake-bakers can add surface features on top of the frosting, such as pingos, rivers, ice roads, wildlife. Sensitive wildlife areas can be omitted from the lease offerings.

BLM'S Competitive Oil And Gas Leasing & Drilling Process is explained at http://www.wilderness.org/Library/index.cfm

Petroleum Game-An Interdisciplinary Adventure at www.geoblox.com

Name _____

# Do the Math

***For this activity:***

- Each oil company has $60 million to start.
- Oil companies share these costs based on their share of the leases:
  - Exploratory wells cost $15 million each
  - Production wells cost $20 million each
  - A processing facility costs $9 million
  - A production well that strikes oil will earn $100 million (in real life, it's not known how much it will earn! It depends on how much oil there is and how fast it can be produced)
- Interest on loans is 10% a year, compounded annually, and it will take seven years to produce oil.

How much should you bid on leases? It's hard to say, but after you spend some of your money on leases, you will need to pool your remaining money with the other companies to pay for exploration and development. If you run out of money you will need to get a loan!

1) If you own half the leases and want to drill four exploratory wells, how much would you have to spend on exploration?

2) If you own only one out of ten leases and decide to drill only two exploratory wells, what would be your share of the cost?

After the Participating Area is determined, you will need to share in the cost of developing the oil. You could end up owning even more of the lease area at this point! Or, less.

3) If your leases make up 70% of the participating area, and you are going to drill 6 production wells, how much money would you need? (Don't forget that you also have to pay for your share of the processing facility!)

4) If you have leased only 5% of the Participating Area, and you only want to drill 2 production wells, how much would you need?

5) If you borrow $12 million how much would you need to pay back, with interest, when the oil is produced?

6) The Explore Oil Company buys 5 out of 10 leases and spends $12 million total on the leases. Three exploration wells are drilled and Explore Oil ends up owning 45% of the Participating Area. Five production wells are drilled. Out of those, one does not produce oil. How much money does Explore Oil make on this deal?

7) How much would Explore have made in 7 years by investing their money with an 8% return (interest)?

**Keep track of your finances here:**

**Leasing:**

Leases your company purchased: _____

Amount spent on leases: _____

Percentage of total leases your company owns:

_____

Money you have remaining: _____

**Exploring:**

Number of wells drilled_____

Total cost of exploration _____

Your company's share of exploration cost _____

Money you have remaining or money you owe _____

**Participation Area:**

What percentage of the Participation Area has your company leased?

_____

**Production:**

How many wells will you drill? _____

With the cost of the processing facility added, what is the total cost of production?

_____

What is your share of the cost? _____

Money you have remaining or money you owe _____

Wells that produce oil _____

Total income from wells _____

Your share of the income _____

Money you have remaining or money you owe _____

Your Profit or Loss _____

**Answers to “Do the Math”:**

1. $30 million
2. $3 million
3. $90.3 million
4. $2.45 million
5. $23,384,605

6. The share of exploration cost is $22.5 million, leaving Explore with $25.5 million. It cost $109,000,000 for production, and Explore has to pay $49.05 million of that. The $23.55 million loan costs $49,892,288 after seven years. The four producing wells earn $400 million and Explore gets $180 million. After subtracting the initial capital, the loan, and the interest, Explore has made about $70,108,000.

7. $42,829,456

## Teacher Background

## Oil Leasing and Unitization

Each year, oil and gas companies lease tracts of land on the North Slope, the Beaufort Sea, and Cook Inlet from the State of Alaska. The leases come with terms that have been set prior to the sale, including the amount that lessees will pay in royalties and taxes on oil produced and the dates on which the leases begin and end.

If a reservoir of oil extends beneath several tracts of land that are leased by different oil companies, problems can arise:

- The first oil company to develop a well might extract all of the oil out of the reservoir and prevent the other leaseholders from getting their share.
- Too many wells might be drilled if each company drills on their own tract. More wells than are necessary cost more and also have more environmental impacts from disturbance of the surface and construction of facilities. Too many wells can also cause reduced pressure in the reservoir and make it more difficult to recover all of the oil.
- It might not be profitable to extract the oil from a small reservoir unless it is combined with larger reservoirs and facilities are consolidated.
- Accidents and oil spills can occur as companies rush to get the oil first.

In order to prevent those problems, oil leases are *unitized*, or joined into a single unit that contains an entire oil prospect. The leaseholders in the unit select a single operator to carry out exploration and development. They share in the costs of developing the oil and also get shares of the oil that is produced, in proportion to how much land they own or by how much of the oil they own beneath the surface. Sometimes unitization may be required by the state; otherwise leaseholders can apply to the state to form their own units.

The lessees get together and identify a prospect and apply to form an exploration unit. The unit includes the tracts or parts of tracts that contain an oil reservoir. They select a Unit Operator to explore and develop the leases.

The Unit Operator and the State agree on the terms of a Unit Agreement. They agree on the Unit Boundaries and on a Plan of Exploration. It tells when they will conduct seismic studies and drill exploratory wells, and when they will apply to form a Participating Area.

The Unit Operator explores by drilling a well, and proposes a Participating Area within the unit, based on findings. The Unit Operator and the state agree on a Plan of Development and on how to allocate the production costs and the oil to the various tract holders. The plan describes the wells that will be drilled and the processing facilities that will be built.

## Cake-Baking Instructions

***Materials Needed*:**

- 2 pkgs white cake Mix
- 1 pkg chocolate frosting
- 1 large rectangular foil baking pan
- Red food coloring to represent “oil”
- Blue, green, and/or yellow food coloring

Cake Preparation: Make layer cake with at least three layers of colored batter. Mix 2 cakes mixes together. Take approximately 1/3 of the batter and set aside. Take the remaining 2/3 of the batter and divide in 3 or 4 (depending on number of colors used) small bowls for coloring. Add a different food color to each bowl (make sure it is dark for that color). Layer all the batters in the baking pan. Use different patterns and thickness while leaving some areas colorless.

Bury a large reservoir of “oil” in one quadrant of the pan (‘northeast”) and a smaller reservoir in the opposite corner. Use a different color to put a “cap rock” over the oil reservoirs.

Baking and temperature will have to be estimated. Temperature should be approximately 25 degrees lower than directions and time will be anywhere from 10 to 20 minutes longer. Check center of cake with toothpick for doneness. Toothpick should be clean and sides pulling away from pan.

Once cake is cooled, frost in the pan to prevent showing any of the cake.

## “Leasing Map”

Cut a piece of paper the same size as the cake and divide it into 10-16 equally sized squares. Give each square a lease number. Mark “North” on the map and also on the cake.

# SPEAKING “SCIENCE”

*anomaly…n*

*porous…adj.*

*porosity…n*

*unitization…v*

*core sample…n*