Make a Fracking Model Activity

Students will design a model to demonstrate how hydraulic fracturing aids in extracting oil and gas from shale deposits thousands of feet beneath the earth's surface.

CREDITS: Activity developed by UCAR AirWaterGas Teachers-in-Residence Shelly Grandell, Tori Hellman, and Rebecca Bradford.[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: 6-12

LESSON FORMAT (CONTENT): Hands-on activity

TIME REQUIRED: Class Time: 1 block period ~100 minutes or two 50-minute class periods.

LEARNING GOAL: Students will understand that horizontal drilling allows for more surface area of host rocks to be fracked after designing a model that demonstrates hydraulic fracturing methods.

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 GROUPS OF THREE/CLASS OF 30

- Gelatin 40 packets, Knox gelatin works well
- Several 20 oz, empty plastic bottles, rinsed (one per group of students)
- Fracking fluid medium. Plaster of Paris works well (good representation of fracking fluid because it is granular and the grains represent the sand (proppant) in the fracking fluid).
- Veterinary catheter tubes, size 10-14 french
- Syringe that compliments catheter tube
- Large straw that catheter tube will thread through

[1] https://www.airwatergas.org/resources/curriculum/make-a-fracking-model-activity/
Modified from the NEED Project Fracturing With Gelatin Activity, found in the Wonders of Oil and Gas Unit.

STANDARDS

Next Generation Science Standards

- ***MS ESS3.A*** *Natural Resources: Humans depend on Earth's land, ocean, atmosphere and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.*
- ***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*
- ***HS-ESS3-2*** *Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. ESS3.A, ETS1.B*
- ***HS-ESS3-4*** *Evaluate or refine a technological solution that reduces impacts of human activities on natural systems ETS1.B, ESS3.C*

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.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.*

LESSON PREP

1. Collect empty PLASTIC water/soda bottles well before lab (have students each bring one in a few days before).
2. Make the gelatin the night before (use 1:4 ratio for more stable gelatin), and pour into the plastic bottles. Cool the gelatin in a refrigerator overnight.
3. In class, before students begin, mix plaster. Make the plaster right before you plan on using it, as plaster hardens quickly.

INTRODUCTION

Show students a picture of a stratigraphic column that contains a deep, tight, oil and gas bearing shale. Ask students to come up with ideas as to how they might access this deposit. Tell them that they may only make a 10-12 inch hole on the ground surface to reach the deposit.

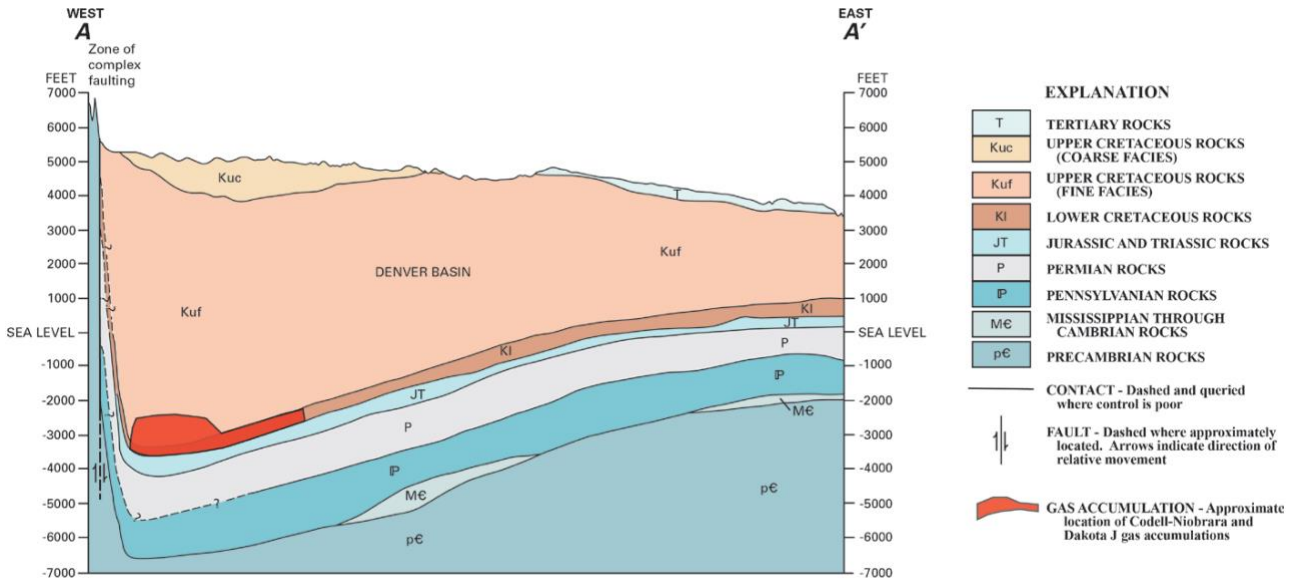


Image Credit: "Gas, Oil, and Water Production from Wattenberg Field in the Denver Basin, Colorado," USGS Open-File Report 2011-1175.

Here is an example from the Denver area: Students would need to access the red bed.

Students will have a variety of answers. Lead the discussion into surface area by asking: How can we access the oil and gas bearing formation beyond the area reached with a vertical well? In oil and gas terminology, traditional drilling technology using vertical wells is called conventional oil and gas extraction.

DIRECTIONS

Begin by passing out all materials to groups, and assembling the catheter/fracking apparatus.

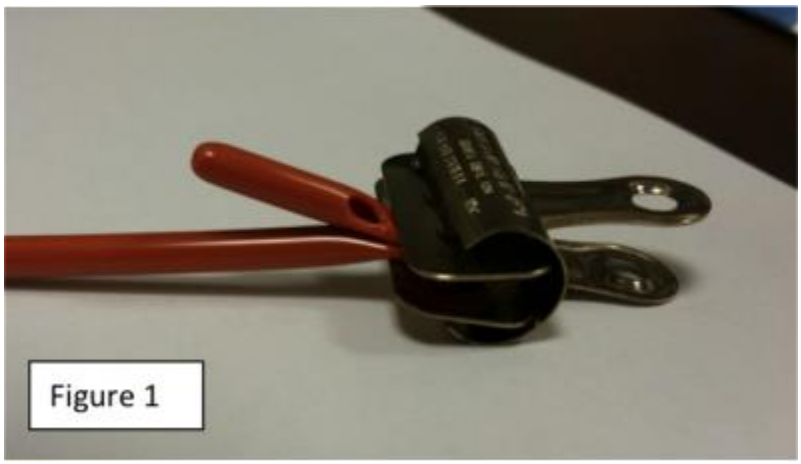
Catheter Assembly:

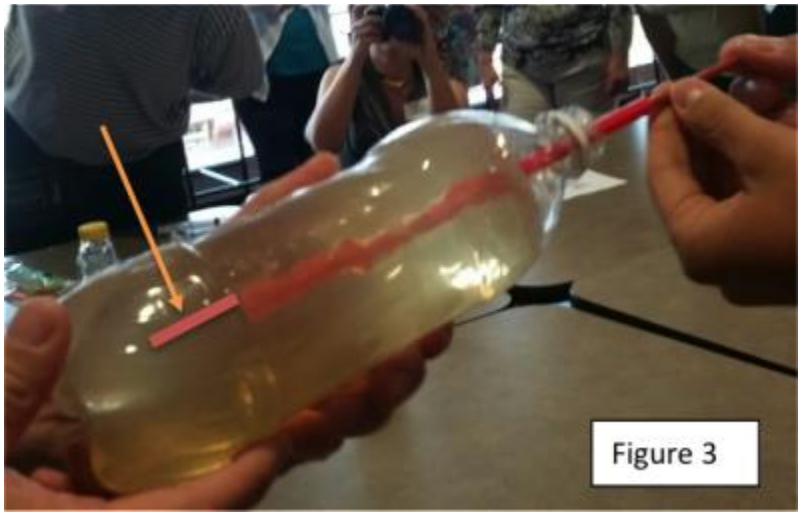
- Attach open end of catheter tubing to a syringe

- Use paper clip or binder clip to pinch bottom of tube ABOVE holes, this will prevent fluid from leaking before injection (see Figure 1).

Procedure:

1. Take bottle with gelatin and lay on side
2. Insert the long, large straw to bore a hole about two thirds of the way through the gelatin to the bottom of the bottle. DO NOT GO ALL THE WAY TO BOTTOM! (see Figure 2)
3. Place thumb over end of straw, pull out slowly, and making sure to extract the gelatin core completely. This is the most difficult step. If there is not enough suction the gelatin core may not come out of the bottle completely, and the experiment won't work if the bore hole is blocked. Tip: You can apply suction with your mouth on the straw to extract the core as well.
4. After clearing the straw, reuse the straw from step 3, and place it into the bore hole, leaving one inch exposed at top of bottle (you will need to hold onto this during injection of fluid (see Figure 2)). This straw will serve as the well casing.
5. Now, using the fracking catheter assembly already constructed, fill the syringe full with the plaster mixture (ie. fracking fluid) while it is attached to the catheter tube, allowing the mixture to fill the tubing until both the syringe and tube are full.
6. Carefully put the plunger back into the syringe, without pushing the fracking fluid out.
7. Now, insert the catheter tubing into the straw, or well casing, until the tube extends past the borehole straw approximately 3 cm. into the gelatin (see Figure 3).
8. Using very firm, steady pressure, push the plunger to inject the plaster into the gelatin.
9. Observe the fracturing pattern of the gelatin.
10. Pull the tubing out of the gelatin carefully, trying not to disturb the fractures.
11. If desired, you can allow the gelatin and plaster to sit until the plaster hardens, and you can then extract the plaster cast of fracture pattern to make further observations by cutting the plastic bottle away and discarding the gelatin.





ASSESSMENT

Students should sketch and label their model and demonstrate an understanding of the relationship between the model and what a real hydraulic fracturing process would look like.

Assessment Questions:

1. Why did you have to apply pressure to fracking fluid to create fracture patterns?
2. How does this model represent hydraulic fracturing?
3. How does this model NOT represent hydraulic fracturing?
4. What improvements could be made to the model to make it more accurate and realistic?
5. How does the plaster simulate fracking fluid?
6. How does the plaster NOT simulate fracking fluid?
7. What does the casing straw represent? What kind of materials would you need to construct casing in the real world? Why?
8. Do you think if you changed the density of the fluid, would the fracture patterns be the same? Why?
9. What is the purpose of the proppant (grains) in the fluid?
10. Why do we hydraulically fracture wells?

Background information:

Access to oil and gas deposits in the U.S have become increasingly accessible through the advent of hydraulic fracturing. Hydraulic fracturing, known as fracking, is the process in which and oil and gas bearing host rock, such as shale, is injected with fracking fluid at high pressures to stimulate flow of hydrocarbons out of the well.

Fracking fluid is a mixture of water with sand and chemicals to aid in flow down the well. Wells used for hydraulic fracturing can be vertically or horizontally drilled. Horizontal wells begin with an initial wellbore (the vertical component) then the hole is gradually turned about 90 degrees to be oriented horizontally within the oil and gas bearing formation. Horizontal wells can spread out for miles. Some single vertical wells can have multiple "fingers" spreading out in different directions inside the oil and gas bearing formation.

For a more detailed description of the fracking process, visit these sites:
http://www.fracfocus.org/hydraulic-fracturing-process
http://www.usgs.gov/hydraulic_fracturing/
http://www2.epa.gov/hydraulicfracturing

EXTENSIONS

Try using different fluids than Plaster of Paris, or vary the density of the Plaster of Paris.

Use activity as an inquiry project. Provide the students with all of the materials and have them develop a design to model hydraulic fracturing. Have the students defend why their model best represents hydraulic fracturing.

ALTERNATE PROCEDURE & MATERIALS

If you are unable to find catheter tubing, you can use two straws with different diameters, with one that fits inside the other. Follow the procedure below:

Straw Assembly:

- About 10 millimeters from one end of small straw, use a push pin to poke about ten holes 5 millimeters apart, with five holes on each side in a straight line.
- Use a small piece of duct tape to seal the perforated end of the small straw.
- Use duct tape to attach a syringe to the non-perforated end of the small straw and insure that no leaks are possible.
- Cut one large straw for the borehole/casing in half and set aside.
- Follow the above procedure starting on step 3.