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HYDRAULIC FRACKING: A Lesson on Energy Resources for Middle and High School

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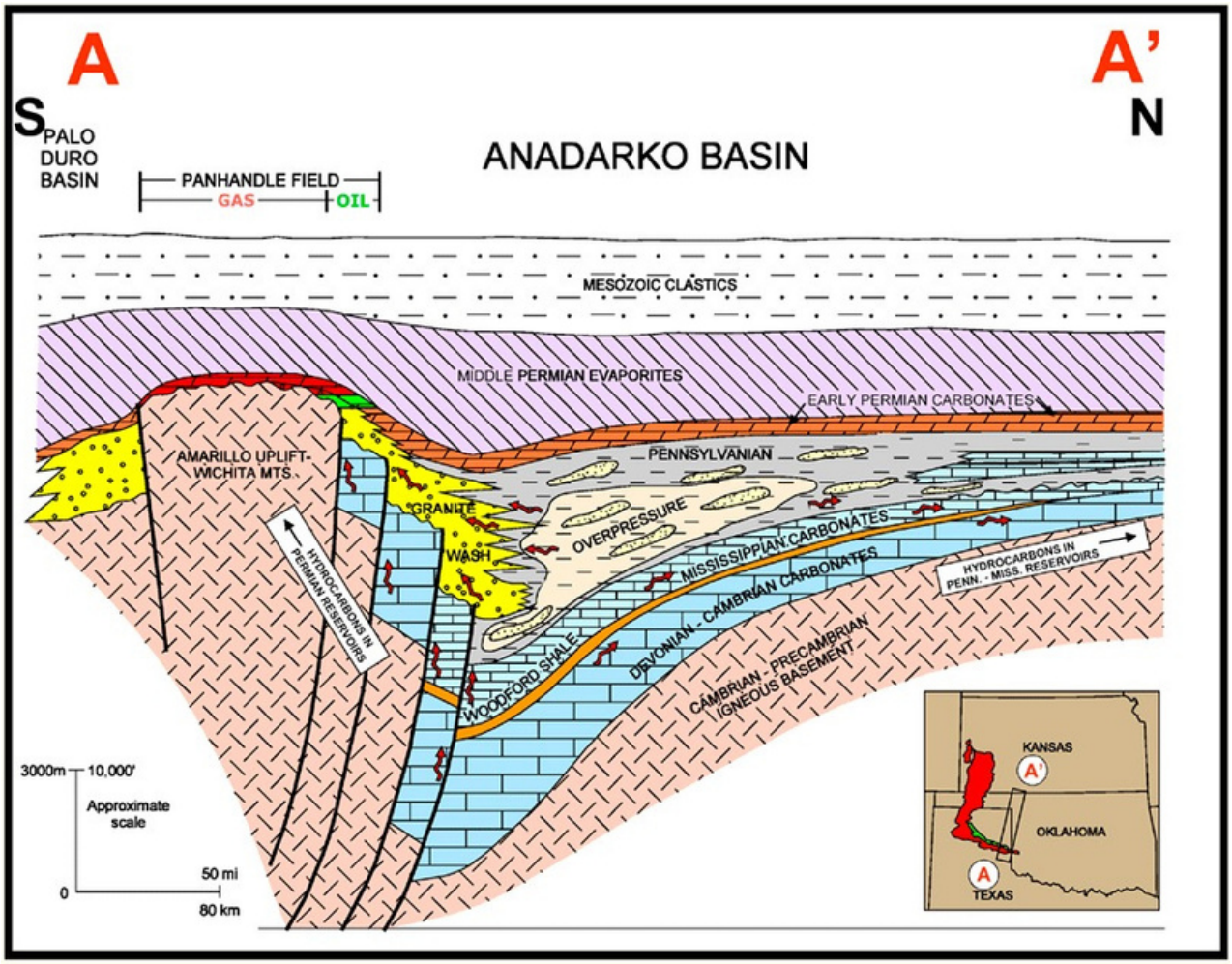
ELABORATE: Hydraulic Fracturing

(See worksheet: *Model Fracking*)

The United States is rich in natural energy resources. We have abundant fossil fuels, especially oil and natural gas, as well as renewable resources such as wind, solar, and biomass. Over the last decade, there has been a surge of interest in utilizing the rich resources of shale plays, which are large shale formations containing significant amounts of natural gas along with some oil. Because shale is a "tight" rock (impermeable), the gas and oil stored there have been unavailable through traditional vertical drilling. However, the process of hydraulic fracturing, or fracking, opens the shale or other tight rock and enables the oil and gas to flow into the well and up to the surface. Fracking fluid is injected into the well at high pressure to start the oil and gas flowing. Fracking fluid is mostly water but also contains a mixture of chemicals, and a proppant such as sand to "prop" the fracture open. The wells can be drilled either vertically or horizontally. Horizontal wells begin with a vertical wellbore, and then the hole is gradually turned horizontally to follow the gas and oil containing formation. There may be several horizontal components from the original vertical wellbore, and they may cover several miles.

In order to understand how hydraulic fracturing helps remove the oil and gas from shale, do the activity *Model Fracking*. To prepare for this activity, the gelatin needs to be mixed, poured, and cooled the day before. For each gelatin bottle, put about 1 cup cold water into a 2-cup glass measuring cup, and empty the 4 packets of gelatin into the water. Allow to sit for a couple of minutes; then stir. Heat the water one minute on high in the microwave and stir to make sure all the gelatin is dissolved. Add another cup of cold water and stir. Pour the gelatin into a clean 18-20 oz. plastic bottle, and place in the refrigerator to cool.

Introduce the activity by showing the students a diagram of a stratigraphic column containing a deep shale play. Discuss with students how and where they might drill to reach the deposit, reminding them that they can only drill about a 10-inch hole to reach the shale. On the next page is an example from the Texas Panhandle. The red and green areas are the bed which contains the oil and gas. Help the students to locate the area shown in the cross-section on the map in the lower right corner.



Lead the discussion to consider how more of the formation could be reached beyond the access of a vertical well since the shale is impermeable.

Then pass out materials and have students follow instructions to model the hydraulic fracturing ("fracking") process.

Figure 1. Bottle of gelatin with large straw inserted

Figure 2. Making holes in smaller straw

Figure 3. Fracked gelatin

ELABORATE: Hydraulic Fracturing ("Fracking") Process Worksheet

Introduction

Shale deposits containing abundant energy resources are often thousands of feet deep within the Earth. They are considered unconventional reservoirs because the shale is impermeable and does not let the oil and gas travel through it into a well. In order to extract the oil and gas, the shale must be fractured, or broken up, creating pathways for the fluids to travel. In this activity, you will model how hydraulic fracturing enables the oil and gas to be brought to the surface. You will see how horizontal drilling enables the shale to be stimulated to produce more oil and gas.

Materials (per group)

- 4 packets of unflavored gelatin
- 2 cups of water
- 1 empty 20 oz. plastic bottle, rinsed
- Plaster of Paris (to represent the fracking fluid)
- Large diameter straw (e.g., smoothie or florist straws)
- Smaller (drinking) straw to fit inside the larger straw
- Packing tape
- Ruler
- Thumb tack
- Syringe, 35mL
- Small bowl and spoon for mixing plaster
- Paper towels

Procedure

1. Mix the gelatin the night before, pour into plastic bottle and chill overnight.
2. Prepare the fracking tube by taking the longer, thinner straw and use a thumb tack to poke 5 holes on each side of the straw in a straight line. Start about 10mm from one end of the straw and make a hole every 5mm on each side. Use a small piece of packing tape to seal the end of the straw nearest the holes.
3. Lay the bottle of gelatin on its side.
4. Insert the large straw, rotating it slowly to bore a hole a little over half of the way to the bottom of the bottle. (Do NOT go all the way to the bottom.)
5. With your thumb over the end of the straw, twist and pull it out slowly so that the gelatin core will come out with the straw. You may have to reinsert and pull again to get all the gelatin.
6. Remove the gelatin core from the straw and carefully reinsert the large straw into the bore hole. It will represent the well casing. Cut off the end of the large straw, leaving about an inch above the mouth of the bottle.
7. Prepare the plaster of Paris by mixing 2 parts plaster to 1 part water, making enough to fill the syringe and straw. (1/2 cup of plaster mixed with 1/4 cup water makes enough for a 35mL syringe.)
8. Remove the plunger from the syringe and put aside. Pinch the end of the straw just above the holes and carefully fill the syringe and straw with the plaster of Paris (fracking fluid) using the syringe as a funnel to fill the straw. You may have to tap it to get the air out of the straw. You can tape the straw to the syringe at this point or just hold it firmly. Reattach the plunger to the syringe without pushing the fracking fluid out. (You may have to dip a little of the plaster out of the syringe. Be sure to have paper towels handy.)
9. Now insert the perforated end of the smaller straw into the well casing straw until the smaller straw extends about 3cm past the end of the borehole straw.
10. Using firm, steady pressure on the plunger, inject the fracking fluid into the gelatin. Observe the fracture pattern of the gelatin.
11. You may leave the fractured gelatin until the plaster hardens and then cut away the bottle and discard the gelatin. The plaster cast of the fracture pattern can then be observed.
12. Sketch and label your model.

ELABORATE: Hydraulic Fracturing ("Fracking") Process Worksheet (cont'd)

Conclusions

There are ways in which this model represents hydraulic fracturing and ways in which it does not represent actual fracking. Think about both the gelatin part of the model and the plaster part. Explain what makes and does not make them good simulations of the actual process.

1. What does the large straw represent? What would well casing actually be made of in oil wells?
2. Can you think of any improvements to the model that would make it more realistic? What are they?
3. If you made the fracking fluid a different density, how might it affect the fracture patterns formed?
4. Actual fracking fluid contains sand grains or other particles. Why are they necessary? (Remember that actual fracking may be taking place a mile or more underground.)
5. Why do oil and gas companies use hydraulic fracturing? What advantages does it have for oil and gas production?

This activity is modified from Make a Fracking Model Activity, developed by UCAR AirWaterGas Teachers-in-Residence Shelly Grandell, Tori Hellman, and Rebecca Bradford and available online at https://www.airwatergas.org/resources/curriculum/make-a-fracking-model-activity/.

For a more detailed description of the hydraulic fracturing ("fracking") process, visit these sites:
http://www.fracfocus.org/hydraulic-fracturing-process