HYDRAULIC FRACTURING EXPERIMENT WITH JELL-O

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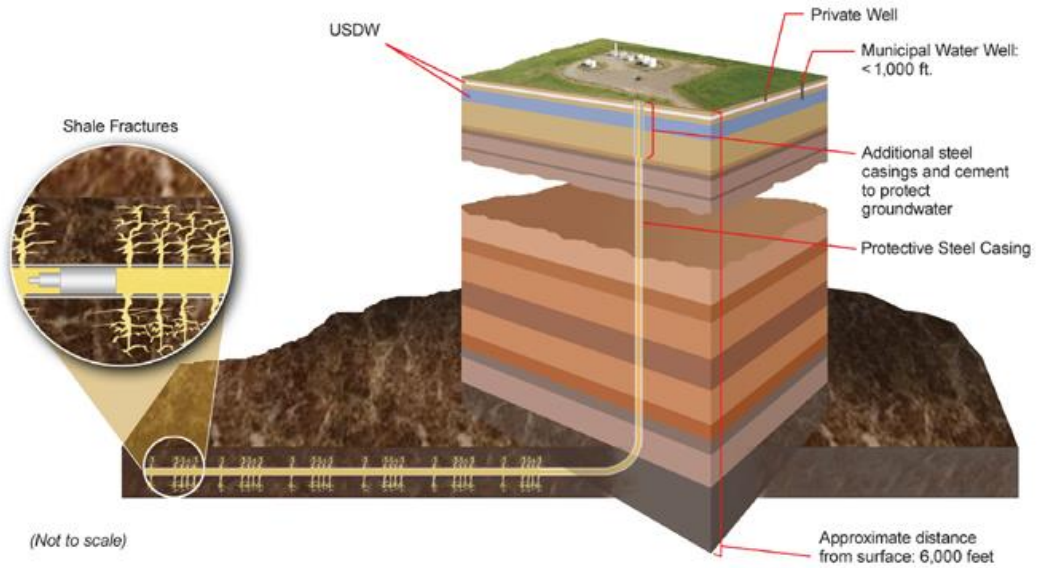
Background Information

Hydraulic Fracturing is an engineering technology that enhances fluid flow into a well from the surrounding rock. Common applications of this technology are to increase production of oil and natural gas fluids from sedimentary rock, and to enable flow of geothermal fluids through different rock types. In oil and gas projects, fluids are trapped in the pore space of the rock. In cases where the pore spaces are very small and not well-connected to each other, flow stimulation is required for economic flow of oil and gas into the well. In geothermal projects, the rock at depth may be hot, but not favor circulation of fluids to bring the heat to the surface through the well. Flow stimulation in the form of hydraulic fracturing allows fluids to capture the heat energy of the geothermal reservoir for use in various applications, such as heating or electricity generation.

To increase flow, engineers must increase the ability of the rock to allow fluids to pass through pores and fractures (or cracks). This important rock property is called *permeability*. Hydraulic fracturing attempts to create additional fractures in the rock, to connect pores and create a network of new pathways for fluid flow. To increase the permeability, *fracturing fluid* is injected at high pressure into the rock to create the fractures. This fluid contains *proppant* – particles that stay in the fracture after fracturing fluids flow back to the well, keeping the fracture open for long term flow enhancement. Sand and man-made ceramic pellets are common proppants added to fracturing fluid. Fracturing fluid also contains substances that reduce friction in the well, acting as a lubricant to make fluid injection easier.



Hydraulic fracturing technology is often used for oil and gas production from rocks with very poor permeability, such as shales. In this diagram, the well is drilled to 6,000 ft vertically before it turns horizontally to set up the hydraulic fracturing program. Note that the hydraulic fracturing takes place well below protected underground sources of drinking water (USDW). Image from "Shale Gas: Applying Technology to Solve America's Energy Challenges," National Energy Technology Laboratory, 2011.

During this hands-on activity, students will simulate hydraulic fracturing of a well to visualize how rocks can fracture when fluids are injected at high pressure. Students will also observe proppant distributed within the fractures. This activity will help clarify misconceptions about the hydraulic fracturing process, for example that explosions do not occur during hydraulic fracturing.

Materials

Jell-O / gelatin (reservoir rock)	Honey (fracturing fluid)	Plastic Syringes (well)
Containers to hold gelatin	Pepper (proppant)	Paper Towels / Trays

TEACHER PREPARATION

- You may wish to put all the simulation materials on a tray lined with a paper towel for students.
- The gelatin will need to be prepared before class. There are many options for containers. The containers being used for the workshop are these snack cups with tops from HEB.
- Use a gelatin color that will allow you to see the fractures (e.g., yellow). Light honey as your fracturing fluid will not be very visible alone in yellow gelatin, but the pepper added as proppant makes it very visible.
- Add pepper to your honey, mix it, and put the fluid into syringes right before the simulation. Otherwise, the pepper will settle within the syringe. 20ml plastic syringes with a tip cap work well for this simulation. Mix a ratio of 15ml honey: 1/8 t coarse black pepper per syringe.

Procedure

1. Obtain a container of gelatin and a syringe containing the “fracturing fluid” and “proppant”.
2. Insert HALF of the tip of the syringe (i.e., the well) into the container of gelatin toward the center.
3. With the tip of the syringe in the gelatin, quickly depress the plunger while holding the syringe steady, emptying the contents into the gelatin.
4. Observe the fractures being created in the gelatin. This simulation demonstrates how fractures propagate within rock during a hydraulic fracturing program.

Discussion and Reflection

- You can design a write-up to accompany this demonstration. Students can create a drawing of their model, label, and describe what happens when the “fracturing fluid” and “proppant” were injected into the “reservoir rock”.
- Discuss with students what they observed and how hydraulic fracturing technology can enhance energy projects involving subsurface wells, such as oil and gas production and geothermal programs.

EXAMPLE STUDENT ANALYSIS QUESTIONS

- How does the honey simulate hydraulic fracturing fluid?
- What is the function of the proppant in the fracturing fluid?
- How do you think the fracture pattern would look different if you used water as the fracturing fluid to replace the honey? Why?
- What are some possible issues or problems associated with hydraulic fracturing? What can be done to reduce the chance of those issues or problems from happening?