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Hydraulic Fracturing (Hydrofracking): The Risks and Rewards of the Controversial Drilling Technique

Fracking—if you're a Battlestar Galactica fan, "fracking" is a coarse term for an intimate activity, as well as being an all-purpose, heavy-duty swear word.

However, if you're in the oil or gas industry, or just read the news relating to upstate New York and eastern Pennsylvania, fracking—or fracing, as it's also spelled—means something very different: hyrdofracking, or hydraulic fracturing. It's a mining or drilling technique used to break up rock underground to create easier access to resources. It's common in oil drilling; incredibly common in natural gas production; and is even used sometimes to revive flagging drinking water wells. It's also used for some solid (as opposed to liquid or gas) mineral resources. For example, it's used at a quarry in North Carolina to break granite blocks out from the surrounding bedrock.

Figure 1 Not an alien probe—a wellhead for hydraulic fracturing, with injection pipes. (image: dpcusa.org)

Despite being in the news of late, it's not a new technique. It was first commercially used in 1903, and was first used in the United States in the late 1940s. At present, thousands of wells use hydraulic fracturing. However, the "gas rush" in the Marcellus Shale formation in upstate New York and Pennsylvania has caused hydraulic fracturing to bubble to the surface of public consciousness: it may now come into widespread use in a densely populated region unaccustomed to fossil fuel resource extraction. Since the process—like most large-scale industrial processes—can have negative consequences, the near-certainty of its widespread adoption in this region has resulted in public controversy, as people weigh the benefits of economic gain against health and environmental risks.

And the debate has been loud, as would be expected when enough natural gas to satisfy US demand for at least a decade is set against possible harm to the water supply for almost 10 million people in one of the world capitals of media, finance, and law. It's not natural gas per se that's sparked a firestorm of controversy, it's the technique—hydraulic fracturing—used to extract it.

So what exactly is hydraulic fracturing?

Hydraulic Fracturing: What It Sounds Like

In a rare case of a scientific or technical term perfectly describing the thing it names, hydraulic fracturing is the use of hydraulic (or liquid; usually water or a water-based solution) pressure to fracture, or break up, rock. As mentioned above, hydraulic fracturing can be used in a wide variety of contexts, from drinking water to granite, but to focus on oil and natural gas, let's start with the basics: oil and gas are found underground, in reservoirs formed by porous (not completely water- or airtight) rock. A common misconception is that oil or gas reservoirs are essentially giant underground caverns, filled with fossil fuel, a misconception fueled by how they are usually depicted (see Fig 2.)

In actuality, however, the oil or gas is not found in enormous voids or hollows in the Earth. Instead, the fossil fuel fills gaps or cracks in rock, or filters through more sponge-like formations. However, while the rock of the reservoir has to be at least somewhat porous to allow the oil or gas to accumulate there in the first place, it may not be porous enough to allow easy or fast flow. In addition, the act of drilling puts tremendous mechanical stress on surrounding rock, heats it up via friction, and also throws off rock chips and dust—all of which can seal off the tiny cracks needed to bring oil or gas to the well. What's needed is to open up larger cracks in the rock, to let the resource flow more readily. Since liquids can be pumped down a well as easily as up, pressurized liquids are used to force open cracks and gaps in the reservoir, similar to how a balloon can be burst by overfilling it.

Water is incompressible; that means that it does not squeeze or compress down under pressure, the way, say, air does. If water or a water-based liquid is pumped into a well at sufficient pressure, it will force open gaps in the rock through which oil or gas can more easily flow.

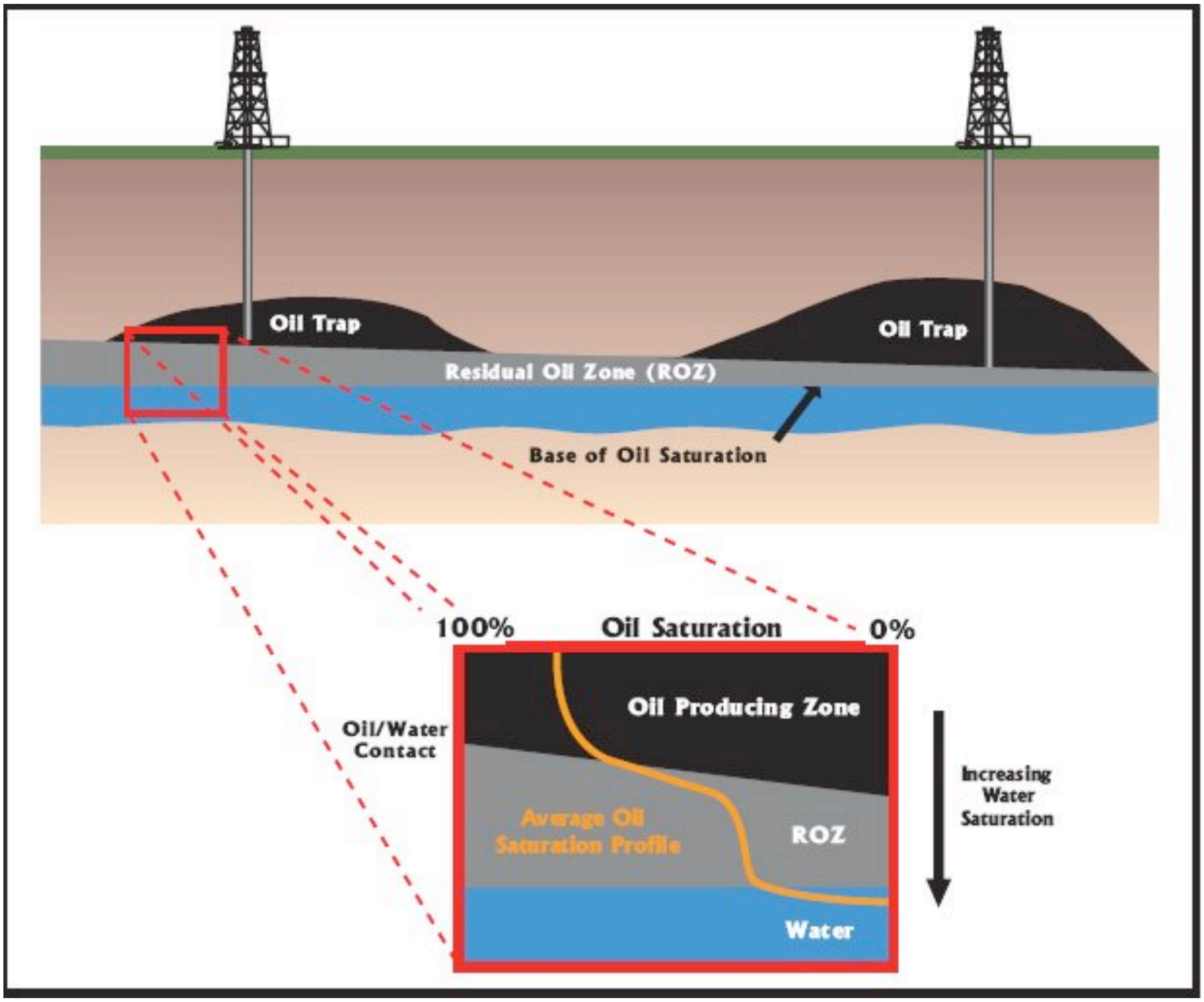

Figure 2 Oil reservoirs in the real world are not as clearly defined as they are in pictures. (image: theoildrum.com)

The pressure involved in hydraulic fracturing is enormous: supercharged pumps can inject fluid at pressures of up to 15,000 pounds per square inch ("PSI"). That's 1,000 times sea level air pressure, the equivalent of having a 7.5 tons pressing on each square inch. Rock that is deep underground is already under enormous pressure, but the pressure of hydraulic fracturing is still enough to break up that rock.

Of course, opening cracks isn't enough—they need to stay open. Something is needed to prop the fissures open, and that something is called a propping agent or proppant. It is a granular material, commonly sand, that is pumped into the fissures to keep them open, like a doorstop. The proppant is injected in a slurry (a liquid-solid mix) that seeps all throughout the network of fissures created by the hydraulic fracturing.

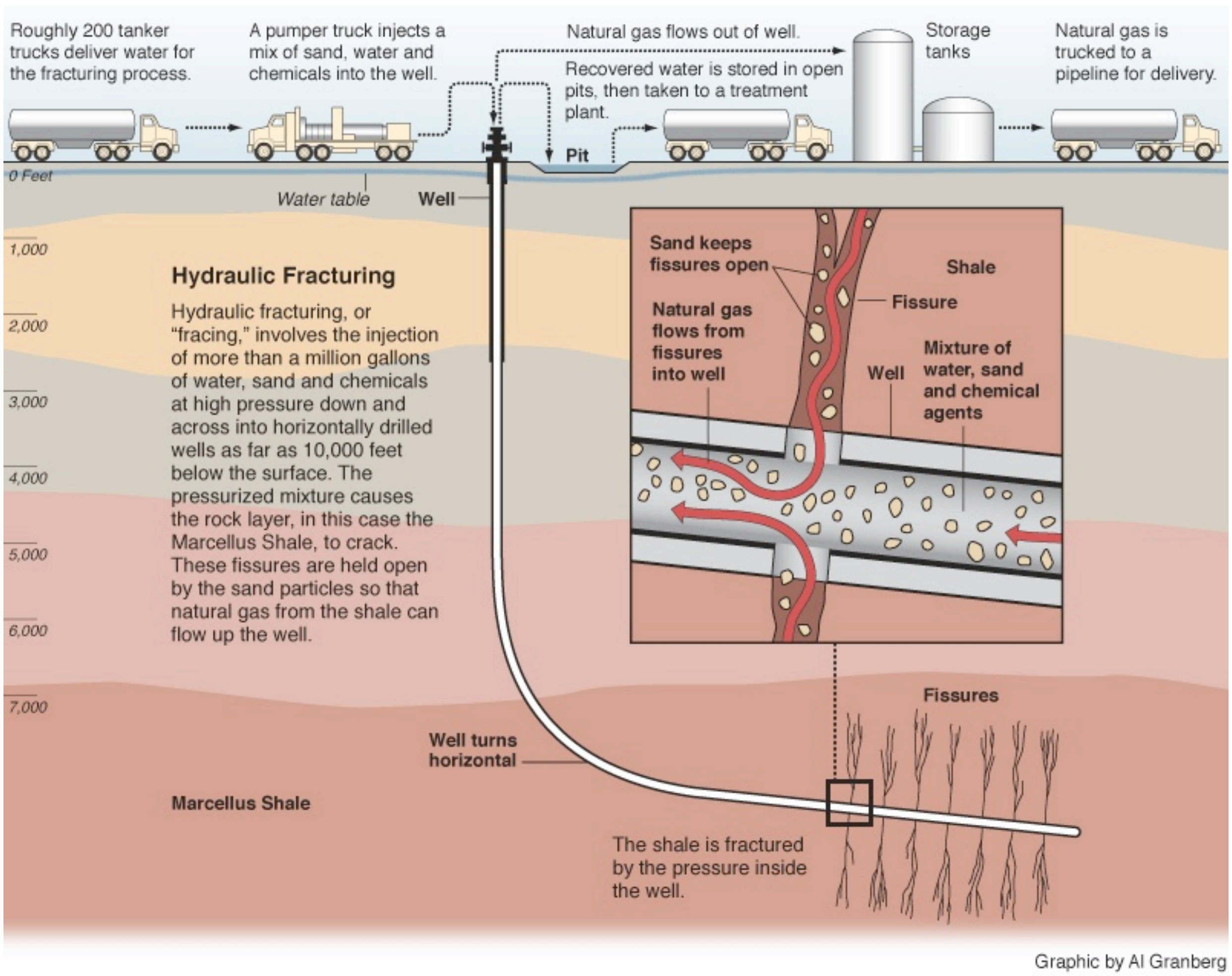

Figure 3 Illustration of hydraulic fracturing (hydrofracking). (image:propublica.org)

How Common Is Hydraulic Fracturing?

It's very common. Many oil and most natural gas wells in the United States use hydraulic fracturing. Sometimes it's used from the beginning, which is usually the case with gas wells. In fact, hydraulic fracturing is pretty much standard operating procedure for working a gas well. Other times, it's used later in a well's service life, when the most accessible oil or gas has been taken and it's time to reach reserves located deeper into the reservoir, further from the well itself.

What Are the Risks of Hydraulic Fracturing?

A tiny, but technically present, risk is that of earthquake—yes, earthquake! Hydraulic fracturing forces rocks apart under tons-per-square inch pressure, and when rock splits and moves that can cause a seismic event, aka an earthquake. However, the sort of seismic event associated with movement of an oil or gas reservoir might typically register in the 2's on the Richter scale, which is a nonevent.

The real risk is pollution. Hydraulic fracturing can be done using nothing but pure water and clean sand—in fact, those are the substances used for opening up drinking water wells. However, for a number of reasons, including cost, availability, and other desired properties, a wide variety of other substances are also used, including:

· Diesel fuel (used because it's more effective at carrying the proppant into fissures than water), which contains benzene, ethylbenzene, toluene, xylene, and naphthalene.

· Polycyclic aromatic hydrocarbons.

· Methanol.

· Formaldehyde.

· Ethylene glycol.

· Glycol ethers.

· Hydrochloric acid.

· Sodium hydroxide.

These chemicals are present in concentrations many times harmful levels. While much of the fracturing fluid is pumped out after doing its job (and it has to be pumped out, to clear the way for oil or gas), it's impossible to get it all. Studies show that 20–40 percent of the fluid will remain underground. Very large quantities of these materials are required; according to an EPA study, from 50,000–350,000 gallons of fracturing fluids are typically used, which would result in a leave-behind or residue of anywhere up to 140,000 gallons. (That's not even counting the 75,000 to 320,000 pounds of proppant used to keep the fissures open.)

The problem is that many of the reservoirs that energy companies want to use hydraulic fracturing to exploit lie in or near USDWs—“underground sources of drinking water.” It’s impossible to aim fissures exactly, or limit them solely to the fossil fuel reservoir. The EPA found that fractures can extend “several hundred feet” into the surrounding rock, which means that fractures will extend into drinking water sources at least some of the time, and that in turn means that hydraulic fracturing chemicals will get into the water.

In its study of hydraulic fracturing and its consequences, the EPA found that “potentially hazardous chemicals may be introduced into USDWs when fracturing fluids are used in operations targeting coal seams that lie within USDWS.” (Note: the study was commissioned in the context of using hydraulic fracturing to extract methane from coal seams; technically, the study’s findings only apply to that one subset of hydraulic fracturing.) Notwithstanding that, the EPA concluded that there was “no conclusive evidence that water quality degradation in USDWs is a direct result of injection of hydraulic fracturing fluids . . . and subsequent underground movement of these fluids.” Instead, the report said that the water-quality problems reported for investigation and review could be attributed to “resource development, naturally occurring conditions, population growth, and historical well-completion or abandonment procedures.”

However, despite the EPA’s assurance, concern remained. There is substantial anecdotal evidence of water-quality problems associated with hydraulic fracturing; and anyway, the EPA is not always accepted as fully nonpartisan, disinterested, apolitical, and objective. Even leaving aside the image of the EPA formed for many of us by Ghostbusters, it’s hard to forget that it was the EPA that pronounced the air at Ground Zero safe for rescue and construction workers. The EPA is part of the executive branch, and it’s not realistic to suppose it immune to politics and political pressure. The EPA that found no risk from hydraulic fracturing was the Bush–Cheney EPA, and Bush and Cheney were advocates of drilling and fossil fuels.

Evidence of Water Contamination

According to public interest and advocacy group Earthworks, communities in at least six states (AL, CO, NM, VA, WV, WY) have reported changes in drinking water quality and/or quantity after hydraulic fracturing was performed nearby. Complaints about drinking water included clouding, black or grey sediments, iron precipitates, black grease, floating particles, diesel fuel or odors, rashes from bathing, reduced water flow, gassy taste, and, last but certainly not least, methane in water. Methane in water supplies is the culprit behind the spectacular flaming tap water some homeowners have experienced.

Are there risks to drinking water from hydraulic fracturing? While the scope of the risk is subject to debate (and is being debated!) the fact that the Energy Policy Act of 2005 exempted hydraulic fracturing from federal regulation under the Safe Drinking Water Act has to be taken as proof positive that there is some risk. After all, if there wasn't any risk to drinking water, there'd be no need to exempt hydraulic fracturing from the Act.

Can Hydraulic Fracturing Be Done Safely? Mostly

The risk of chemical contaminating drinking water can be substantially reduced by fairly simple measures:

· Use only clean sand and water, or, if you need to use other substances as well for a given project, use only nontoxic additives. Nontoxic additives are available—they are used in offshore wells, to prevent contamination of the marine ecosystem and food chain (which includes seafood that human beings eat).

· Use steel holding tanks for the residue of hydraulic fracturing—the excess fluid which is pumped or escapes back to the surface—instead of storage pits which are prone to leakage.

· Don't use hydraulic fracturing in watersheds or the midst of aquifers that provide drinking water. That's why Chesapeake Energy, bowing to public sentiment and political pressure, has agreed to not drill in the upstate New York watershed.

Of course, there are costs to all of these measures. Limiting the fracturing and proppant compounds that can be used may increase monetary costs and/or decrease efficiency of hydraulic fracturing. Steel holding tanks cost more than gouging out a holding pit. And not drilling in watersheds or above aquifers means passing up on some natural gas.

However, even if these precautions are taken, there are still environmental and health risks–radioactivity, for one. Water samples brought up by drilling in New York, in the Marcellus Shale formation (see below), show levels of radium-226 at close to 300 times the limit for safe discharge into the environment—and thousands of times safe drinking levels. Since hydrofracking and drilling in "hot" formations will result in radioactive water being brought up, there may sometimes be a level of environmental and health risk which is effectively irreducible.

That seems like it may be the case in New York, with regards to the Marcellus Shale. Water samples from drilling are radioactive, and the state simply does not have the facilities to decontaminate or filter the wastewater to be free of radiation.

Case in Point: The Marcellus Shale

The Marcellus Shale is an underground rock formation running from parts of northern Kentucky and eastern Ohio through upstate New York. It's suspected to hold up to 500 trillion cubic feet of natural gas, of which up to 10 percent (50 trillion cubic feet) may be accessible by advanced drilling and hydraulic fracturing techniques. The accessible amount is a two-year supply for the US, with a "wellhead" value of around $1 trillion. If somehow the entirety of the reserves could be tapped, that would be two decades (!) of natural gas. The core of the Shale gas reserves lies in New York and Pennsylvania, which is why most of the attention—and controversy—has swirled around drilling in those two states.

Hydraulic fracturing is a "must" for gas extraction from the Marcellus Shale. The as deposits are too diffuse, and the rock too impermeable (preventing the gas's easy movement) for practical recovery otherwise. Therefore, to talk about drilling in the Marcellus Shale is to talk of hydraulically fracturing the formation—hydraulic fracturing here is not a technique to increase productivity near the end of a well's lifetime, as it often is for oil drilling, but instead is an integral part of drilling from day one.

Part of the area overlaying the Marcellus Shale and its gas is the watershed feeding the Catskills reservoirs that provide water to New York city and some of the surrounding counties—over 9 million people. The risk of water contamination from the hydraulic fracturing chemicals—or from the radioactive "brine" brought up by drilling—is so great that the New York City Council called for a ban on drilling in the 8 percent of the Marcellus Shale formation associated with the city's watershed. Drilling in that area could endanger the water supply of close to 10 million people—or require a $10 billion water filtration system to be built, and $100 million per year spent operating and maintaining it. The cost of this filtration would increase water and sewer costs for New York City residents by at least 30 percent.

So: chemically tainted water, radioactive water, even potentially flammable water. Seems like it should be an easy decision to make: don't hydraulically fracture where there are people, or drinking water supplies.

On the other hand, there's $1 trillion of recoverable gas—enough gas to for the whole country for two years. There are jobs in construction and drilling. There are tax revenues, and lease payments or gas royalties to land owners. As the president of a pro-drilling group of upstate New York landowners, the Steuben Landowner's Coalition, points out, the Marcellus Shale offers enormous economic benefits and an alternative to foreign oil.

What do you do? Do you pass up on all that gas, all that money, and jobs? Or do you protect the environment and drinking water supplies? Ideally, you do both, but some tightropes are dangerous to walk—if you contaminate the drinking water for close to 10 million people because the risks were not properly assessed, you can't just call a mulligan and do it over.

At a minimum, it's important to understand the potential gains and risks to make an informed decision. And in particular, since gas drilling, especially in deposits like the Marcellus Shale, is so dependent on hydraulic fracturing, it's important to add the costs (monetary or otherwise) of hydraulic fracturing to the other costs of extracting the gas when evaluating whether, where, and to what extent recovering the gas is worthwhile.

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