THE TRUTH ABOUT HYDRAULIC FRACTURING

My reason for beginning this site was to advocate the study of geology and answer the age old question "Why should I care?". To do this, I like to write about topics which demonstrate how much geology affects your every day life. Therefore, despite the overwhelming coverage of the topic and how well others have written about it, I'd be remiss if I did not devote a post to the oil and gas recovery technique known as hydro-fracking. Much of what I've written here has been addressed in one way or another in articles all over the web. What I hope to accomplish here is to provide accurate information and to pull together different topics and concerns into one place where you can feel confident that you are being provided factual information with none of the fear mongering or cover up nonsense.

What is hydraulic-fracturing?

Hydraulic fracturing – aka "hydro-fracking" or simply "fracking" – is a technique most often used by oil and gas companies when they install a new recovery well into a gas/oil-bearing geologic unit. The hydro-fracking process is implemented after a well is installed, but before recovery begins. At this stage, a mixture of water, sand, and various other chemicals are injected into the well under pressure in order to spread open and propagate new and pre-existing joints and fractures in the geologic unit of interest.

Why is it used?

The hydro-fracking process has been used since the late 1940's for a variety of reasons, including groundwater, geothermal, and waste storage applications. One of the most notable uses of hydro-fracking is oil and natural gas recovery, where it is utilized to enhance recovery of these resources in the subsurface. The technique increases the permeability of a geologic unit, which allows liquid and/or gas to move more freely toward the recovery well and, therefore, significantly increases production at the wellhead.

In recent years, drilling technologies have advanced and oil/gas-bearing geologic units previously believed to be too cost-prohibitive to drill are now becoming the center of attention. Enter the shale gas.

Shale is a sedimentary rock which can have a high porosity (small voids within the rock which can store oil and/or natural gas), but has a very low permeability (stored fluids cannot move through the rock easily, if at all). Fractures already exist in the shale, but are typically very tight, hairline fractures which don't permit much movement of fluids. This made recovery from these units uneconomical without the use of fracturing techniques which would increase secondary porosity (fractures and joints). By opening and extending these fractures and joints, the oil and gas is now easily recovered.

Even with hydro-fracking being used for decades, shale gas was considered too hard to recover because these fractures only propagate outward from the well so far…you wouldn't reach much gas without putting a dense grid of wells over a large region. With the invention of horizontal drilling, this problem was solved. A company can now drill vertically down to the geologic unit of interest (the Marcellus Shale in Pennsylvania, for example), then change direction and begin drilling horizontally along the length of the unit. In addition, multiple wells can be drilled from a single location on the surface. Shale gas is now not only recoverable, but profitable.

How is it accomplished?

It's all about stress. At depths sometimes reaching 20,000 feet below the surface, you can expect great amounts of confining pressure. This pressure tends to hold fractures tightly closed. By introducing an incompressible fluid (water) and putting it under enough pressure, these fractures may be spread open. This same process is also capable of creating new fractures. By pressurizing the water, you reduce the effective stress of the rock and cause the minimum principle stress to become tensile. When the minimum principle stress (now tensile) exceeds the tensile strength of the rock, fractures are induced parallel to the maximum principle stress direction (perpendicular to the minimum principal stress).

All open fractures are immediately filled with sand grains which were mixed in with the pressurized water. The main purpose of the sand is to prop open the fractures. Remember, once the pressure is removed from the water, the original confining pressure will return. Without the sand in place, that pressure would close all the new fractures. The sand not only prevents fractures from closing, but is a highly permeable medium for fluids to pass through, ensuring the fractures will continue to serve as efficient conduits for recovery.

Concerns with hydro-fracking

Hydraulic fracturing has been blamed for creating many hazards to humans and the environment. However, how credible are claims of fire-breathing faucets and earth-splitting quakes? To understand the possible threats, we must understand the geology of the location being "fracked".

Earthquakes

Earthquakes seem to be on the rise this year and, according to many media outlets, the culprit is hydro-fracking. Rather than believing everything you hear on the television or internet, do yourself a favor and treat yourself to some light research before developing a strong feeling on the subject. If you did, you'd probably find out that we're not experiencing any more earthquakes than usual. Statistically speaking, we're right on track.

But when earthquakes happen in areas thought to be safely away from common sources, like fault zones and plate boundaries, folks are quick to blame hydraulic fracturing. Such was the case when the magnitude 5.8 earthquake hit near Washington, D.C. on August 23, 2011. One of the first fingers pointed was directly at hydro-fracking. Besides, what else could it be? There was no large fault zones in the region, and Virginia is about as far from a plate boundary as you can get. The hitch was that there were no fracking operations near the focus of the quake, either.

Many people don't realize that you don't need a plate boundary or large fault system to experience an earthquake. True, these definitely help and tend to be where you get the larger quakes, but small earthquakes happen all over. Ohio, for example, has experienced nearly 200 earthquakes of magnitude 2.0 or higher in its recorded history, with a 5.4 magnitude quake occurring in 1937, well before hydro-fracking techniques were ever used.

However, anthropogenic sources for earthquakes have been well documented. Many of these involve injection of fluids into the ground (especially along fault lines) for waste storage or enhanced recovery techniques. Additional induced seismicity has been documented after large volumes of fluid like groundwater have been removed from the ground (large-scale ground subsidence), or when new reservoirs are filled(increased overburden pressures). The U.S. Department of Energy touches on this subject, as well.

It is important to note that hydro-fracking *does* cause earthquakes! If you think about it, the process is creating fractures in rock which is buried miles beneath the surface. This is obviously going to result in seismic events recordable on a seismograph. The distinction is the magnitude of these events. In most cases (and by most, I mean nearly all) the conditions present at a project site result in "micro-quakes", or those that can only be detected by extremely sensitive instruments. It should go without saying that these "earthquakes" cannot be felt and definitely won't cause damage at the surface.

In certain cases, like in the UK this past month, the site's geology may make it more susceptible to earthquakes. In this example, multiple minor earthquakes of magnitudes up to 2.3 (in April 2011) occurred in the vicinity of a hydraulic-fracturing operation being conducted by Cuadrilla Resources. An investigation into the cause of the quakes led Cuadrilla to the conclusion that the waste water injection wells (associated with hydro-fracking operations) most likely triggered these earthquakes. However, the unique geologic conditions at the site – namely, the presence of a fault zone – made the site more at-risk than most. Even so, the largest of the possibly induced quakes was barely enough to be felt at the surface, and led to no damage.

Even with the knowledge that fracking-induced earthquakes are possible with the right geologic setting, it's not something to start blaming for every earthquake which we don't expect. Such was the case above as well as other locations, such as theNovember earthquakes in Oklahoma. A look at the geology of this are showed that the Magnitude 5.6 earthquake occurred on an existing fault line which had been building stress for millions of years.

As far as fracking-induced earthquakes, the UK example is pretty well worst-case scenario. Meaning, this is one concern we shouldn't be wasting our time worrying about.

Groundwater Contamination

If you do want something to worry about, here's where I'd start. Hydro-fracking gets its name from the vast amount of water ("hydro") it uses to fracture ("fracking") the geologic unit. However, water is not the only thing being pumped into the ground. As we already discussed, sand is mixed with the water in order to prop open induced fractures and maintain a high permeability. But water and sand are just the main ingredients, multiple other chemicals are added to the mix and make up about 1-2% (by weight) of the fluids being injected into the well.

Why all the chemicals? They all have their uses: biocides keep algae and other organisms from growing in the well network, acids polish the metal well casings to keep metal shavings from damaging the pumps, other chemicals adjust fluid viscosity and act as emulsifiers. While some of these chemicals are perfectly safe (even for consumption), many can be toxic or carcinogenic.

According to the U.S. House of Representatives Committee on Energy and Commerce, over 2,500 hydraulic fracturing products containing 750 chemicals and other components have been used between 2005 and 2009. In the same report, the committee has compiled a list of all 750 chemicals known to be used in hydraulic fracturing applications.

Hydro-fracking fluid is the "secret sauce" of the gas and oil world. While we may know what chemicals could be in the mixture, the concentrations of these chemicals are "trade secrets" and, therefore, companies do not have to reveal how much of any chemical is in use. In other words, any concentration of products could be used, and the company is OK to use it as long as they tell the customer (permitting agency) that they used some combination of milk, eggs, and peanut (BTEX components, methanol, and boric acid).

The main concern here is groundwater contamination. Millions of people get their water from groundwater resources. When you're pumping unknown concentrations of multiple (sometimes tens or hundreds) of chemicals into the ground, you want to carefully monitor where those chemicals go. Until recently, no such monitoring was taking place. In fact, oil/gas companies claimed that their process recovers most (~99%) of these chemicals once fracturing was completed, and that was good enough for them.

This year (FINALLY) the U.S. Environmental Protection Agency began one of the first large-scale studies on the effects of hydraulic fracturing on groundwater resources. The study will monitor wells at varying distances from hydro-fracking operations in seven different study locations across the United States. The idea being, if high concentrations of chemical X are detected around fracking sites, and diminish as you move farther away, there is a high likelihood (if not certainty) that fracking operations are the source of chemical X in groundwater. According to the U.S. EPA website, preliminary results will be available by the end of 2012, with the final report completed in 2014.

Another study conducted by the University of Texas at Austin, Jackson School of Geoscience (JSG) has already yielded preliminary results, which shows *no direct link*between hydro-fracking and groundwater contamination at any of the sites they studied. I believe the EPA study will show the same. Why is this? Most drinking water aquifers (porous, permeable geologic units which act as reservoirs for groundwater) are within several hundred feet of the surface while most hydro-fracking operations take place many thousands of feet lower. The chances that existing or induced fractures create hydraulically conductive pathways vertically between thousands of feet of rock is very slim, even with the induced pressures caused by hydro-fracking.

The JSG study did identify more likely sources of contamination. The first is surface spills of waste water associated with hydro-fracking operations. Any fluid used to "frack" the shale is recovered and either recycled for use in the next well, or disposed of. If this fluid is spilled on the ground, the same chemicals may seep down through the surface sediments and rock, eventually making its way into an unconfined aquifer.

However, if you're going to look at surface spills for a reason to shut down hydro-fracking, you should also shut down sources of surface spills which can exceed those done by fracking operations. Dry cleaning facilities (perchloroethylene) and at least 80% of gas stations (BTEX compounds, methyl tertiary butyl ether, polynuclear aromatic hydrocarbons, and a host of other chemicals) have leaks *all the time.* I've worked full-time for years dealing with environmental remediation for these sites. If the leaks weren't there, I'd be out of a job. Scary statistic: over 2,000 confirmed underground storage tank system releases are currently in corrective actions in the state of Ohio alone. I'm not justifying spills of any kind, just pointing out that they're not exclusive to hydro-fracking.

Speaking of leaks, the second indirect source which JSG noted was leaking of fracking fluids from the well itself. If the well casing was not installed properly, there's the possibility that some fluid could leak through a seam in the casing as it passes through the aquifer (remember, in order to get to the shale to frack it, you have to first drill vertically down through the overburden rock, including any aquifer). If this happens, you're putting chemicals directly into the groundwater. Again, the hydro-fracking itself isn't actually causing this contamination. Of course, the chemicals used for fracking wouldn't be there to contaminate anything if hydro-fracking wasn't taking place. The issue here, however, is competency in the well installation process. Well installation needs to be conducted the right way every time in order to avoid any leakage. If there's fracking fluid leaking from the well casing, their product (oil or gas) will leak, too…meaning lost profits. It's in the company's best interest, to make sure this doesn't happen.

Another concern with groundwater contamination isn't due to the fracking fluids, but the release of naturally occurring methane gas. This is thought to happen when induced fractures create pathways for the gas to "leak" out of a fracked geologic unit, and make their way into overlying aquifers and into our drinking water. There was a famous case, demonstrated in the documentary "GasLand", where a homeowner turned on a faucet in their home and was able to light it on fire due to the amount of methane gas present. A number of homeowners have reported this problem following the commencement of nearby hydraulic-fracturing operations.

Two things to note. One: these are all properties where the residents have private water wells supplying their home, usually in deeper aquifers. So if you receive municipal water, you shouldn't worry. Two: geology, geology, geology. Methane, as I mentioned, is naturally occurring (it *is* natural gas). In fact, it occurs all throughout the stratigraphic column in the areas of Pennsylvania, New York, and West Virginia where these claims are common. A study by Penn State explains that sources of methane in water wells can range from gas wells, coal mines, landfills, and simply natural deposits.

Does this mean that hydro-fracking was not the cause of methane in drinking water supplies? No. But it also means it's not definitely the source, either. In Pennsylvania, where the "fire faucet" was documented in "GasLand", a number of the residents jumped on the bandwagon of blaming hydro-fracking for methane in their wells. However, in the same area, multiple residents reported that they've always had methane in their water, as long as they've lived there and well before hydro-fracking began. In the same area, methane deposits are naturally occurring in geologic units where it can easily be recovered by water wells.

Of course, the EPA recently published results from a study in Pavillion, Wyoming where methane in water wells had a similar isotopic signature as methane from deep sources – near the depth of fracking operations – and did not match that of shallower deposits of methane usually associated with "natural contamination". So, it's a definite possibility and one that needs to be studied more.

What does it all mean?

From everything I've come across, these two concerns pretty well cover most common "threats" associated with hydraulic fracturing operations (many other concerns fall under groundwater contamination). We've established that earthquakes pose effectively no risk to people or structures at the surface. Groundwater contamination, on the other hand, is where our concerns should lie. Even then, preliminary studies show it's not the actual fracking that's causing problems, but a lack of consistent, regimented installation practices which prevent surface spills and leaking at any point in the well casing.

The general public and government both need to better understand this process and should insist on more strict regulations of well installation and hydro-fracking operations. Required monitoring programs should be in place to protect groundwater resources by taking background (pre-operation) samples and comparing these with samples taken throughout and after the fracking process. If this is done consistently, it would lead to identification of well sites where leaking is taking place, and if it shows no changes in groundwater chemistry, this could even redeem hydraulic fracturing from the stigma it's associated with. I'd say this is a pretty good incentive for oil/gas companies which have been claiming how safe this practice is for years without any proper, scientifically sound evidence.

What we all need is proof. With the finalization of the JSG study, and the upcoming results of the U.S. EPA, we'll at least have a couple reliable sources for reference. You can bet that these will spark new studies to verify the results, which will give us even more scientific studies to look to for a springboard to action (or sense of relief) on the issue.

Let's wrap it up already!

I recently attended a meeting in Pittsburgh, PA, where I spoke with a high-level geologist with the Pennsylvania Geological Survey. As Pennsylvania is currently one of the hydro-fracking hot spots in the country, our conversation inevitably led to the controversies that surround the process. I was happy to learn that the majority of geologists who study the geology in "fracked" regions have the same views as expressed above, and that the enhanced recovery of fossil fuels can be very economically beneficial. Unfortunately, many residents don't fully understand all the variables involved (namely geology), and see it as a definite menace. For this reason, legislation banning the practice of hydro-fracking gets passed in cities or counties across the country.

One thing that stuck with me from my conversation with the PA Geological Surveygeologist, was his closing remark (so to speak): "I hope Ohio doesn't make the same mistake Pennsylvania did." By this, he meant that there's been a lot of resistance to hydro-fracking in PA…though it's still in use (and doing pretty well). He explained that he fully supports the practice – while agreeing that there needs to be more strict oversight to ensure less chance of cutting corners (resulting in spills and leaks) – and thinks Ohio residents should embrace hydro-fracking techniques as a way to exploit the Utica Shale gas reserves.

Final Thought

A lot of what I've written seems to be supporting hydraulic fracturing. I do feel the process is no more hazardous than other methods of natural resource exploitation. However, I feel obligated to stress that the truth about hydraulic fracturing is that there are definite problems which need to be resolved in order for us to be certain that the technique is safe. By conducting multiple, unbiased scientific studies on the effects of hydro-fracking on groundwater supplies and the environment, I believe a solution may be found. Whether it will favor either side of the issue, I don't think anyone really knows for certain. With what I do know, I can make the educated guess that we won't be seeing hydraulic fracturing disappearing anytime soon.

Source : http://adventuresingeology.com/2011/11/23/the-truth-about-hydraulic-fracturing/