- Backgrounder -
SHALE GAS AND FRACKING

February 16, 2012

At the AAAS Annual Meeting in Vancouver, a symposium on hydraulic fracturing, including two Canadian participants, scientists will release a new report:

Hydraulic Fracturing of Shale

Embargoed until Thursday, February 16, 2012: 12:00 p.m. PST (3:00 PM ET)

Canadian Speakers: David Layzell, University of Calgary and John J. Clague, Simon Fraser University, and also including Raymond Orbach, Chip Groat, and Danny Reible; of the University of Texas at Austin.

News briefing: 12:00 p.m. Thursday, Feb 16

Event: 1:30 p.m. Friday, Feb 17 — Hydraulic Fracturing of Shale: Building Consensus Out of Controversy

Hydraulic fracturing (fracking) for shale gas involves injecting a fluid into gas-containing rocks in order to release and capture the gas reserves within. Fracking has gained attention globally from the public, from the media, and from scientists in the many disciplines linked to the application of this technology. Our backgrounder below is designed to help you separate fact from fiction on this complex, emerging, and expanding technology that is being used to exploit unconventional reserves of natural gas.

As always, if you'd like some help locating a Canadian expert to interview on this or any other science stories, we are on the ground at the AAAS. Please call us at **613-249-8209**.

Additional stories you want to cover at the AAAS meeting in Vancouver? Let us know! We're here to help.

Register with SMCC (click on the "For Media" tab at www.sciencemedia.ca) to access references, additional resources, and a list of Canadian experts available for media interviews about fracking. Or call us at **613-249-8209.**

Shale gas and fracking

What is shale gas and how is it formed?

Marcellus shale along Rt 174, Marcellus, NY
Source: Wikimedia Commons, Lvklock

Shale is the world's most common sedimentary rock. It is soft and finely grained, usually comprised of compacted layers of mud or clay and fine mineral particles such as quartz and feldspar. Some shales contain organic material (kerogen) making them an important source of natural gas. Shale often cracks and splits apart easily.

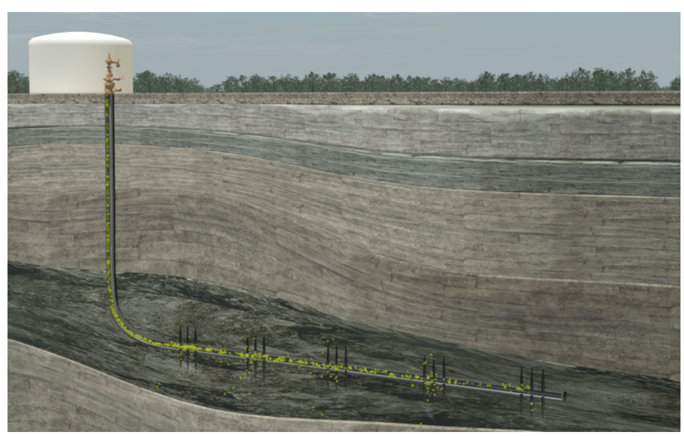
Shale gas, a mixture of gases trapped within layers of shale, includes the gases methane, ethane, propane, butane, and trace quantities of argon, helium, neon and xenon. Methane, the largest constituent of shale gas, is a valuable fuel widely used for household heating, cooking, power and steam generation, and as a transportation fuel in the form of compressed natural gas (CNG). Methane acts as a greenhouse gas when it escapes into the atmosphere, with a heat-trapping potential at least 21 times more powerful than carbon dioxide (by weight).

How is shale gas formed?

There are two ways of forming natural gas: via thermogenic or biogenic processes. Thermogenic natural gas — the source of shale gas — is formed deep underground as leftovers from dead organisms (usually the remains of algae) are compressed and heated over millions of years. Biogenic natural gas, usually formed at much shallower depths, is produced and released over a much shorter time frame by microorganisms decomposing organic matter — such as plant residue — in the absence of oxygen. Some shallow shale gas deposits may have large amounts of biogenic gas.

How is shale gas different from conventional natural gas reservoirs?

In conventional natural gas reservoirs, a permeable rock such as sandstone is capped by a layer of impermeable rock (usually a shale), creating a seal and forming a reservoir below. Gas migrates into the reservoir from the source rocks and gets trapped, so by drilling a well into the gas pocket, gas can be extracted. In contrast, shale gas has not migrated but instead is scattered in millions of tiny bubbles, adsorbed and trapped over a very broad area in rock pores, cracks and the remaining carbon-rich organic matter. As a result, a different technique, known as hydraulic fracturing, is necessary into order to release and collect the trapped gas in an economic manner.



Hydraulic fracturing using horizontal drilling to capture shale gas.
Image credit: The University of Texas at Austin.

Where are the shale gas reserves in Canada?

Within Canada, shale gas deposits are found in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, and Nova Scotia. Various stages of shale gas exploration activities are underway in each of these provinces. It is likely that additional shale gas resources will be found in sedimentary basins in the Northwest Territories, the Yukon, Nunavut, and offshore Newfoundland and Labrador.

Map of shale gas regions: NEB - Energy Reports - Understanding Canadian Shale Gas - Energy Brief
http://bit.ly/xGaOtj

What is hydraulic fracking and what does it involve?

Hydraulic fracturing, also known as hydrofracking, or fracking, is a process that uses liquid pumped in under pressure to break (fracture) this weak, brittle rock, creating many fracture channels in the shale so that the gas may flow out of it more quickly.

Before fracking begins, geologists use 2-D and 3D imaging to identify “sweetspots” — deposits that are easiest and cheapest to extract. Geologists first drill vertical boreholes from 500 to 1500 m deep to identify the amount and composition of gas in the area. Computer models further aid in predicting how much gas is in the shale, and how best to develop it. For development of the resource, once the required depth is reached, vertical wells are steered to become horizontal, thereby contacting more shale for gas extraction. Shale gas reservoirs now being developed lie between 1 and 3.5 km deep, and the horizontal sections can stretch as long as 2 km. Drillers can install many branches from a single horizontal well to increase the amount of gas that can be recovered from a reservoir while minimizing disturbance of the adjacent land. Multiple layers of metal casing and cement are placed around the well bore to protect the upper beds and seal the well. Then the fracking fluid is injected under high pressure to crack the shale.

Once the shale is broken and channels to the gas are established, these channels to must be kept open to allow the gas to flow freely to the well. Fractures in the rock are kept open by pumping in a mixture of water (~95%), fracking fluid (0.5-2%, see below), and sand (~4-5%), a process called “propping.” Fracking fluid is specially formulated to help keep the injected liquid flowing, to protect the steel casing from corrosion, and to prevent microorganism growth which could impair the quality of the gas. Gas inside the well is driven to the surface by the natural pressure that is released when the rock is fractured. Gas is then sent to a treatment plant where it is processed and placed into pipelines for transportation to consumers.

Schematic diagram of the process at: http://fracfocus.ca/hydraulic-fracturing-process

Why the recent focus on shale gas exploitation?

We've known about shale gas for decades and fracking has been used in North America for more than 60 years to maximize recovery from oil and gas wells. By 1980 there were thousands of vertical shale wells producing natural gas commercially from the Appalachian basin in the eastern US. The two key technological advancements that have increased recovery rates and recently made shale gas economically viable over a wider geographic area are horizontal drilling methods and multistage hydraulic fracturing. Multi stage fracking means the same fracking process is repeated two, three or many more times.

Areas of scientific uncertainty and/or controversy

Some scientists have questioned the environmental impacts of fracking. The main concerns raised are earthquakes, air and water contamination, the large volumes of water required for fracking, and the greenhouse gas implications of extracting, transporting, and utilizing this resource.

Does fracking cause earthquakes?

There has been much debate about this issue. A 2011 British report suggested a link between shale gas hydrofracking and small earthquakes, and suggested that quakes are likely caused by water lubricating the rocks, increasing fluid pressure and making it easier for rocks to slip. According to some studies, earthquakes caused by fracking in shale beds are rarely greater than 4 in magnitude, a level considered not dangerous or damaging, and whose sensation is similar to that of a passing freight train. It's not yet known whether small earthquakes linked to fracking activity could trigger larger ones. Experts are investigating recent quakes of 4.0 and 5.6 in Ohio and Oklahoma that occurred where active fracking was underway. These larger quakes have been linked with disposal of flowback liquids, rather than being directly due to fracking for gas production. The large volume of wastewater flowback is sometimes disposed of by re-injection into deep boreholes.

Does fracking cause water contamination?

Underground aquifers are an important source of drinking water in many regions. These aquifers are generally found at much shallower depth than shale gas deposits. Nevertheless concern exists about whether shale gas fracking can result in contamination of the water resources above.

1) Water contamination with methane

Depending on the geology of the area, methane can naturally occur in groundwater. Methane is a colourless, odourless gas that is considered non-toxic when ingested, however it can cause suffocation at high concentrations in enclosed spaces and is highly combustible at certain concentrations. One way to determine whether increased levels of groundwater methane is due to fracking activity is through isotopic signatures.

Background levels of naturally occurring methane in groundwater usually originate from biogenic activity close to the surface, such as gas from decomposing plant matter. Methane liberated from shale as a result of fracking is predominantly thermogenic - produced by heat and pressure of ancient organic matter over millions of years. Biogenic and thermogenic methane have different isotopic signatures. Gas mixture composition also provides clues as to the origin of the dissolved methane. Naturally occurring methane in groundwater typically doesn't contain other gases like ethane and propane that are found in shale gas, so the presence of these gases is another clue that fracking may be the cause.

In the only peer-reviewed study published so far on this topic, methane contamination of drinking water in northeastern Pennsylvania and northern New York was attributed to fracking activity using these isotopic methods. However, micro seismic studies at thousands of shale gas hydraulic fracturing sites in the US indicate that the possibility of hydraulic fractures reaching ground water is slim because of the way stresses are distributed in the subsurface. This significant body of evidence suggests that hydraulic fractures are not necessarily the culprits behind water contamination by methane. Additional research is required to demonstrate how excess methane in the aforementioned study reached the drinking water.

2) Water contamination with fracking fluid

The fracking fluids injected into shale gas well bores consist of water mixed with friction-reducing chemical additives, a process called “slickwater fracturing.” These additives help the fluid to carry the proppant (sand) more easily and at reduced pressure than if water alone were used. Other additives include biocides to prevent microorganism growth in wells and fractures; chemicals to prevent corrosion of metal pipes; and acids that are used to remove drilling mud damage near the well bore.

The precise chemical composition of the constituents of fracking fluid has been difficult to obtain because oil and gas companies consider the composition of these mixtures to be trade secrets, and because most legislation doesn’t require their disclosure. Fracking fluid includes from forty to over seven hundred different chemical compounds. Some jurisdictions have recently enacted mandatory disclosure of the names and concentrations of chemicals used in fracking fluid, such as rulings in Colorado and Texas, that require chemical ingredients for new fracturing operations to be uploaded to a public national chemical disclosure registry. In November 2011, the EPA announced it would start rulemaking under the Toxic Substances Control Act (TSCA) to collect unpublished health and safety data on fracking fluids.

According to the BAPE (Bureau d'audiences publiques sur l'environnement) report investigating fracking in Quebec, among the products used in Quebec’s Utica shale, 8 have known carcinogenic properties. In a report for the US Government completed in April 2011, 750 chemicals used in fracking were examined. The most widely used chemicals were methanol, isopropyl alcohol, 2-butoxyethanol, and ethylene glycol. The report identified 29 chemicals known to pose a risk to human health which included hazardous air pollutants and human carcinogens such as benzene. BC recently mandated chemical disclosure for the constituents of fracking fluid. A number of industry associations, such as the Canadian Association of Petroleum Producers (CAPP) have also called for and agreed to greater transparency, full disclosure of the fluids used, and to aggressively pursue more environmentally acceptable alternatives.

Industry has argued that fracking fluid represents just 0.5% of the injected fluid. Nevertheless since millions of litres of water are used at each well, with several wells per region, the total volume of chemicals in fracking fluid could have significant impacts on living organisms. This is an area of significant scientific uncertainty. Very few peer-reviewed studies have assessed the possible toxic effects of fracking fluids in the environment. However, as indicated above, the distribution of stresses in the subsurface mean that the possibility that liquids injected for hydraulic fracturing will reach groundwater is slim. Environmental reviews are underway by the government of Quebec, by the EPA, and by the Council of Canadian Academies (report due in 2013).

3) Contamination by displaced deep layer water (radioactivity, toxic elements)

Between 15 and 80% of the injected water returns to the surface after fracking, and its composition is presumed to be a mixture of the injected water combined with fracturing fluids and salty water that fracking has displaced from deep underground (called deep formation water). Deep formation waters often contain high concentrations of salts, other dissolved solids, toxic elements, and naturally occurring radioactive materials, with radioactivity as high as 3200 times that considered the standard for drinking water.

In the only peer-reviewed study to have evaluated the hydrochemistry of drinking water at sites within and beyond 1 km from a fracking operation, no evidence was found for well-water contamination from deep formation mixing. Scientific uncertainty remains regarding this issue. Some reports speculate that it may take several years for displaced deep formation water to be detected at the surface after fracking operations.

Volume of water used

Fracking requires large volumes of water. An estimated one to eight million gallons of water is used per well. The waste water (flowback) from fracking must be temporarily stored, potentially disrupting or displacing natural habitats. Waste water must be treated at facilities that critics say may not be adequately equipped to remove the contaminants. Where local geology is suitable, operators inject waste water back into the ground, a practice that has been linked to induced earthquakes. As yet, no studies have assessed the risks of contaminated waters that remain deep underground after fracking.

Gels, foams, and compressed gases, can also be used for fracking, including nitrogen, methane, and carbon dioxide, and research into fracking techniques that don't use large volumes of water is in progress.

Air pollution and greenhouse gas impacts

The total life cycle assessment of greenhouse gas emissions from fracking operations (from exploration through to use as fuel) is the subject of intense debate within the scientific community. Some studies, including those published in 2011 by scientists from Cornell University, and by the EPA indicate that shale gas development produces significantly more GHGs than does conventional natural gas, and may in fact be more GHG intensive than coal or oil. Other studies, such as those by scientists at Carnegie Mellon University, Cornell University, the US National Energy Technology laboratory, and Argonne Laboratory, challenge these calculations, arguing that natural gas is the cleanest fossil fuel.

Legislative Aspects

Within Canada, the environmental impacts are currently being studied by an expert panel of the Council of Canadian Academies, at the request of federal environment minister. The results of this inquiry are expected in 2013. The state of New Jersey and the city of Buffalo, New York have recently banned the practice or issued moratoriums on new development. In Quebec, a moratorium is in effect within the St. Lawrence River and Estuary, and fracking has been suspended while a strategic environmental evaluation is underway. Suspensions, moratoria, or bans are also in place in New South Wales, Australia; South Africa, France, and Bulgaria.

Expert Reviewers

- Roberto Aguilera, Professor, Conoco-Phillips Chair in Tight Gas Engineering, Schulich School of Engineering, University of Calgary.
- Maurice B. Dusseault, Professor, Earth and Environmental Sciences, Engineering Geology, University of Waterloo.
- John Molson, Canada Research Chair: Quantitative Hydrogeology of Fractured Porous Media, Département de géologie et de génie géologique, Université Laval.
- David Layzell, Executive Director, Energy and Environmental Systems Group, Institute for Sustainable Energy, Environment and Ecolomy, University of Calgary.
- John Clague, Shrum Research Professor, CRC Chair in Natural Hazard Research, Department of Earth Sciences, Simon Fraser University.
- and additional anonymous scientist.