MARCELLUS SHALE NATURAL GAS DRILLING IN NORTHEAST PENNSYLVANIA

An Independent Research Project By William Garro and John Luff

Natural Gas Drilling History

In the United States natural gas drilling has been occurring since 1821 with the purpose of using the gas as a fuel. The first well, measuring only 27 feet deep and located in Fredonia, New York, produced enough gas to light "two good candles". (1) In 1850 the well was deepened to 70 feet and provided enough gas to power 200 burners. With the success of the wells drilled in New York and later in Titusville, Pennsylvania the concept of natural gas drilling became very popular and drilling along the Lake Erie shoreline increased. The area of these wells, ranging from Pennsylvania into New York along Lake Erie is located onto of Devonian shales which are organic rich rock strata containing natural gas deposits. By the beginning of the twentieth century natural gas wells had become so common that almost all homes and industries in the area of Lake Erie used natural gas from the shale. In the early 1980's, with low gas prices and poor technology drilling in the Devonian shales decreased.

Regional Geologic Settings

During the Devonian Period, approximately 400 million years ago, organic rich black-shale was deposited into the Appalachian Basin. Shale is a fine grained, sedimentary rock that forms in areas of slow moving or stagnant water where fine clays or mud settle and accumulate. These fine grain particles become compacted into rock. Shale has characteristic parallel layers and micro-sized, inter granular pore spaces. It is in these layers and pores where the natural gas is trapped. The Marcellus Formation and its dominant shale lithology, located about a mile below the surface, is the most common type of Devonian Shale located in Pennsylvania, New York, Ohio and West Virginia.

Natural Gas Potential

In the state of Texas companies are drilling into the Barnett shale, having produced over 2.5 trillion cubic feet (tcf) of gas already and an estimated 30 tcf still trapped. Pennsylvania, according to estimates, has anywhere from 350 tcf to 450 tcf of gas, which would take the United States 14 years to use. Terry Engelder, a geosciences professor at Penn State University, believes there is 400 tcf of natural gas in the Marcellus shale and current production is around 438 million cubic feet per day. There are currently 375 wells permitted as of the end of 2007. Using current technology only about 10% of the gas released from the pores is recovered, however many believe with new technology that number can be raised up to 20%. Companies have also attempted to re-frac existing sites in order to reopen pores spaces and increase the release of natural gas from the shale.

Field Work

During the course of this study field work was conducted by our team. The goal was to find Marcellus Shale outcrops, areas where the shale is located at the surface, for examination. At each of the sites the strike, dip direction and dip magnitude were taken (Table 1.) as well as samples and pictures. The first site examined was located in Lehighton, Pennsylvania where three out crops were observed. The first outcrop is along the road located at the west side of the Route 209 Bridge in south Lehighton (site name MAR01). Farther south on Route 209 two more outcrops were observed (sites MAR02 and MAR03). At all three locations black to dark grey shale and coarser-grained siltstone were observed. The second trip was to Bushkill, Pennsylvania. Here the our team found three more outcrops, the first along a road cut on Route 209 (MAR04), the second near the Bushkill Falls (MAR05), and the third next to a rock quarry (MAR06). Hand sample descriptions of the Rock samples were made. All of the samples displayed the same similar characteristics; fine grained texture, black to dark grey in color, tight parallel layering, and very brittle.

Data

Table 1.

Site Name	Strike	Dip Direction	Dip Magnitude
MAR01	260°	178°	23°
MAR02	64°	154°	24°
MAR03	48°	148°	20°
MAR04	55°	325°	29°
MAR05	N/A	N/A	N/A
MAR06	235°	325°	23°


MAR 01


MAR 03

On December 5th our team went to Troy, Pennsylvania on a site visit sponsored by Fortuna, a gas company drilling in the state. The visit included three sites in different stages of completion, the first site was still in the drilling process, the second had a well head in place and was preparing to collect gas and the third site was in the process of removing the last of the frac water still in the well before collection could begin. On the site large red containers were line up to hold the water before and after the fracing process.

Environmental Concerns


Source: http://www.thebackpacker.com/trailtalk/thread/52481.php

Traditionally a process known as "hydro-fracing" is used to open pore space in a gas reservoirs, allowing the gas to escape. Hydrofracing generally involves pumping a fluid such as water or kerosene and, usually, sand or some other granular material into the gas reservoir under high pressure until the rock cracks. However, due to the low permeability of the Marcellus Shale conventional hydrofracing cannot be used. Hydrofracing performed in the Marcellus Shale incorporates a gel into the pumping fluid and uses significantly more water, 500,000 gal.-1,000,000 gal., compared to 5,000 gal. – 50,000 gal. used in traditional hydrofracing. Having to use such large amounts of water presents numerous environmental issues, thus, Pennsylvania's Department of Environmental Protection (PaDEP) has worked with the Susquehanna and Delaware River Basin commissions and the oil and gas industry during the creation of the drill permit application process. The end result is a thorough application process designed to protect Pennsylvania's water resources. Some key requirements of the application are:

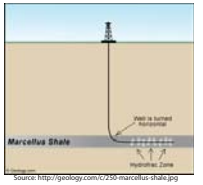
- Type of well with proposed location plotted on a U.S. Geological Survey topographical map showing property lines and horizontal bores;
- Acreage to be disturbed by drilling and operations;
- Sources and locations of water to be used in the drilling process, the impacts of drilling on water resources, and proof that the water withdrawals have been approved by the appropriate river basin commission;
- Location(s) of treatment facilities where drilling and fracing fluids will be taken for treatment and disposal; and
- Size and locations of proposed dams and water impoundments

On average the permitting process currently takes about nine (9) months to complete and be approved or disapproved.

A main issue that hinders the application process is not so much the water use, but rather the disposal of the fracing fluid. Once the frac fluid has been used and it is pumped out of the drill hole it contains water, a proprietary "mud" mixture, and most importantly brine (salt). Currently in the common wealth of Pennsylvania there are only a few waste treatment plants with the ability to treat such waters. More importantly, the few treatment plants available to treat the drilling waste water are all located in Western Pennsylvania, creating a transportation issue for drill sites located in North Eastern Pennsylvania, which makes it more difficult to get a permit. One solution currently being looked at is the use of portable treatment stations in which waste fluids are treated on site and then recycled into drilling process. This process is still in the early stages however and is not currently being used.

Another issue surrounding the waste frac fluid is its temporary storage, which is commonly done in a lined detention basin that has been dug into the ground. General concerns surroundinging these basins are that the lining can fall into the basin, the lining may be punctured, or the basin may overflow in the event of a large rain event. All of these situations would allow the waste fluids to leak out of the basin and absorb into the surrounding soil. Once in the soil the waste fluid has the potential of reaching and contaminating the surrounding groundwater.


Source: http://www.thebackpacker.com/trailtalk/thread/52481.php

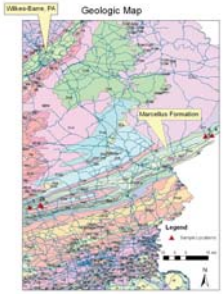


Source: http://geology.com/r/256-marcellus-shale.jpg

Drilling Process

Note: The main type of drilling done in the Marcellus is rotary drilling. In rotary drilling the drill pipe has a rotary bit attached to it, and is powered using air pressure or water pressure.

The average depth of the Marcellus shale is between 4,000 ft. and 7,000 ft. below the surface which is far below any water aquifer that may be tapped for use as a well. This leaves a chance for contamination of the aquifer from the drilling process. To prevent contamination a couple of steps are taken. The first step is to use only pressurized air drilling when going through aquifer (preferred method of drilling anyway because it is much faster than drilling using hydraulic power). The second step is to encase the drill hole with concrete throughout the entire aquifer, which ensures that no water can infiltrate up through the well and into the aquifer. Once through the aquifer air drilling used until the rock becomes too hard and air is no longer sufficient to spin the rotary point. Once the rock becomes too hard the drill bit is turned using hydraulic power, which is much slower but also more powerful. When the switch is made to a hydraulic rotary a "mud" is also constantly circulated during the drilling process. This mud serves the dual purpose of keeping the drill bit from over heating and it pumps out any rock fragments generated during the drilling process. The next step to drilling in the Marcellus is to switch to horizontal drill. In this process a series of one degree bits are used to turn the pipe 90 degrees, this allows for more of the gas to be reached with just one drill hole. After the pipe has been turned it is time to start opening up pore space and extracting the natural gas. Traditionally a process known "hydrofracing" is used to open pore space in a gas reservoirs, allowing the gas to escape. Hydrofracing generally involves pumping a fluid such as water or kerosene and, usually, sand or some other granular material into the gas reservoir under high pressure until the rock cracks. However, due to the low permeability of the Marcellus Shale conventional hydrofracing cannot be used. Hydrofracing performed in the Marcellus Shale incorporates a gel into the pumping fluid and uses significantly more water, 500,000 gal.-1,000,000 gal., compared to 5,000 gal. – 50,000 gal. used in traditional hydrofracing. Once the rock has been fractured and propped open the gas begins to flow out freely and is extracted to the surface.



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