The Marcellus Shale is a Devonian-age rock formation deposited over 350 million years ago in a shallow inland sea located where the present day Appalachian Mountains now stand. The shale contains organic matter that has been compressed and heated deep within the Earth creating hydrocarbons which include significant quantities of natural gas. New technology for the development of natural gas from unconventional reservoirs has made the Marcellus Shale an important energy resource.

The Marcellus Shale extends from southern West Virginia, western Maryland, and eastern Ohio northeastward through Pennsylvania and into the southern half of New York (Figure 1). The production of commercial quantities of gas from this formation requires the use of large quantities of water to fracture the rock. Concerns about the source of the water supply needed for the fracturing and questions about the disposal of the fluids recovered during the operation have been raised by a number of water resource agencies and citizens throughout the Marcellus Shale gas development region.

In central New York, the bedrock gently dips to the south at the rate of 40 to 50 feet per mile (Figure 2). The Marcellus crops out at the land surface in an east-west band, generally south of the New York State Thruway. The rock unit was first described in geologic terms near Marcellus, New York—hence, its name. While the bedrock sequence across the state gently dips to the south, the thickness of the Marcellus Shale varies from east to west across the state (Figure 3). In the eastern part of the state the formation can be over 300 feet thick, but it thins to the west, down to about 150 to 100 feet thick in the south central part of the state. It thins further west down to around 25 feet. Therefore, the greatest area of interest for development of the Marcellus Shale will most likely be from the central southern tier to further east where the shale is most thermally mature and has the highest organic (methane) content.

While the thickest part of the Marcellus Shale is found in the eastern part of the state (Figure 3), the zone of greatest organic content is found in the lower part of the Oatka Creek and all of the Union Springs Members of the Marcellus Formation (a geologic term, Member means a unit or layer within the Formation). The upper part of the Oatka Creek Member is a gray shale with lower organic content and may be of less interest to the gas industry.

Why Marcellus Shale is Important Gas Resource

Natural gas in shale occurs in fractures, in the pore spaces between individual mineral grains and chemically adsorbed onto organic matter (Soeder, 1988). To produce commercial amounts of natural gas from such fine grained rock, higher permeability flowpaths must be created into the formation. This is done using a technique called hydraulic fracturing, commonly referred to as “hydrofracking” or “fracking.” A hydrofrac is where water under high pressure forms fractures in the rock, which provide pathways for gas to move to the well. Petroleum engineers refer to this fracturing process as stimulation. If the hydraulic fractures are able to intersect sets of natural fractures, a network of flowpaths can be created to allow the gas to easily flow to the well.

In 2008, two professors at Pennsylvania State University and State University of New York at Fredonia estimated that about 50 Tcf (trillion cubic feet) of recoverable natural gas could be extracted from the Marcellus Shale (Engelder and Lash, 2008). In November 2008, based on production information from Chesapeake Energy Corporation, the estimate of recoverable gas from the Marcellus Shale was raised to over 363 Tcf (Esch, 2008). The United States uses about 19 Tcf of natural gas per year, so the Marcellus gas resource may be large enough to supply the needs of the entire nation for nearly two decades.

What has spurred development of the Marcellus Shale was a new application of existing drilling technology known as directional drilling, which has produced natural gas successfully from the Barnett Shale in Texas. This drilling process involves steering a downhole drill bit in a direction other than vertical. In the Marcellus application, the initially vertical drill hole is slowly turned 90 degrees to penetrate long horizontal distances, sometimes over a mile long, through the shale bedrock. The horizontal hole is then segregated into smaller (about 500 foot)
segments using what is called a straddle packer. Multiple hydraulic fractures are created in the rock along the length of the horizontal bore hole and the fractures are held open by sand sized proppant material. This process allows a large number of high permeability pathways to contact an enormous volume of rock (Figure 4).

According to Range Resources (2008), one of the first major horizontal drillers of Marcellus Shale, these wells typically produce gas at a sustained rate of about 4 MMcf (million cubic feet) per day. Over its lifetime, each horizontal well on an 80-acre spacing can be expected to produce a total of about 2.5 Bcf (billion cubic feet) of gas at an estimated production cost of $1.00 per Mcf (thousand cubic feet).

**Concerns about Developing Natural Gas Wells in Marcellus Shale**

Large amounts of water are required for the stimulation of a Marcellus Shale gas well. Fluids recovered from the well, including both the liquids used for the hydrofracturing and any produced formation brines, must be safely handled, stored, treated and disposed of properly. Three important environmental concerns related to Marcellus Shale gas production are:

- Supplying the large amounts of water needed without impacting local water resources
- Avoiding degradation of small watersheds from increased erosion and sediment as large quantities of equipment and supplies are moved about on unpaved rural roads
- Determining the proper methods for the safe disposal of the large volumes of spent and recovered fluids from the wells

These concerns are described in more detail here:

**Water Supply:** Drilling the horizontal leg of the drill hole requires large amounts of water to create a fluid mud that both cools the bit and carries the rock cuttings back to the land surface. After drilling, the shale formation is then stimulated with hydraulic fracturing, which may require approximately one million gallons of water per one thousand feet of the horizontal section of the drill hole. Many regional and local water management agencies are concerned about where such large volumes of water will be obtained and what the possible consequences might be for local water supplies. Under drought conditions, or in locations with already stressed water supplies, obtaining the millions of gallons needed for a shale gas well could be problematic. All states require that water withdrawals not impact instream ecology; therefore, water withdrawals must allow a certain percentage of “passby” flow to insure that downstream aquatic conditions are not impacted by the withdrawal. During summer low flow conditions, withdrawal of water for any reason would be prohibited, as was observed in Pennsylvania during Summer 2010. The Susquehanna River Basin Commission prohibited withdrawal of water from several streams as summertime drought related, low flow conditions were considered critical for the protection of aquatic species in those streams. The withdrawal permits were temporarily suspended until flows increased in the affected streams.

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Transporting Fluids and Supplies: During the 1970s, hydrofrack treatments of tight sandstone gas wells in the western United States involved moving large amounts of equipment, vehicles and supplies into remote areas. Marcellus Shale hydrofracks will require similar or greater amounts of equipment. Transporting all this equipment and supplies to drill sites via rural New York State roads could potentially create roadbed instability, damage bridges and culverts, cause erosion, and threaten local surface water bodies with sediment runoff. Of equal concern is the potential for spills or leaks into watersheds as the fluids and chemical additives are transported and handled. Under current Marcellus production levels in Pennsylvania, complaints of rural road damage and traffic disruption from drilling equipment have been received, suggesting that this could be a significant problem if multiplied out across thousands of active drill sites.

Wastewater Disposal: For gas to flow out of the shale, water injected into the well during the hydrofrack treatment must be recovered. The recovered water is known as flowback water and what might be contaminants in this water is of concern. While the percentage of chemical additives in a typical hydrofrack fluid is commonly less than 0.5 percent by volume (Figure 5), the quantity of fluid used in process is so large that the additives in a three million gallon hydrofrack job, for example, result in about 15,000 gallons of chemicals being transported to the site, mixed and then injected into the formation. Along with the introduced chemicals, hydrofrack water is in close contact with the rock during the course of treatment, and when recovered it may contain a host of formation materials, including brines, heavy metals, radionuclides (radioactive contaminants) and organics that complicate wastewater disposal.

In addition to recovered hydrofrack fluids, brines from within the shale formation itself present wastewater disposal challenges. These formation brines commonly contain relatively high concentrations of sodium, chloride, bromide, and other inorganic constituents, such as arsenic, barium, other heavy metals, and radionuclides that significantly exceed drinking water standards. Disposal of these fluids might involve some form of industrial pre-treatment before disposal, or injecting the hydrofrack fluids back into the ground at greater depths than the Marcellus into permeable formations such as the Oriskany or Potsdam Sandstones. New York presently has a handful of permitted injection wells; therefore, this disposal technology will need to be developed in the near future if it is to be considered a viable option.

Drilling Status in New York

Natural gas is an abundant, domestic energy resource that burns cleanly and emits the lowest amount of carbon dioxide per BTU (British thermal unit) of any fossil fuel. The Marcellus Shale and other natural gas resources in the United States are important components of a unified national energy program. Marcellus gas development has begun in the northern Appalachian Basin with significant number of permitted wells throughout Pennsylvania and West Virginia. Because of questions related to water supply and wastewater disposal, however, the New York State Department of Environmental Conservation has placed moratoriums on drilling until these issues have been addressed through the Supplemental Generic Environmental Impact Statement (SGEIS). At the time of this writing, the SGEIS is being revised based on numerous public comments. Following final revision and adoption of the draft SGEIS, development of this natural gas resource will cautiously move forward in New York State.

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References


