Jointing and Fracturing in the Marcellus Shale

A discussion of natural fractures, or joints, present in the Marcellus Shale and the hydraulic fractures that are induced during unconventional gas drilling to extract natural gas.

Introduction

The Marcellus Shale is a natural gas-bearing rock found beneath the surface of the Earth in parts of Pennsylvania, Ohio, West Virginia, and New York. It was deposited in a shallow sea that covered these states nearly 400 million years ago. Shale is a type of sedimentary rock formed from very tiny, flat grains packed together like decks of cards strewn across a table. Grains found in the Marcellus Shale accumulated together as muds—along with a large quantity of organic material—in the shallow sea. Some of the organic material trapped in the mud has matured (changed chemically with heat and pressure) into natural gas. The natural gas now present in the Marcellus Shale remains mostly trapped between the grains and in natural fractures already present in the shale. Economically extracting the natural gas tightly trapped by the shale grains requires a process called hydraulic fracturing. There are various types of hydraulic fracturing technology, but all hydraulic fracture jobs aim to create or extend a network of joints, or fractures, in the shale that allows the trapped natural gas to flow into a natural gas well.

DID YOU KNOW?

- Fractures are commonly known by geologists as 'joints.'
- The difference between joints and faults, like the San Andreas system of faults, is that faults have experienced marked directional movement along the fracture, whereas joints only experience separation.
- Even though water is used, the “hydro” in hydrofracking doesn’t refer to water. It references the hydraulic pressures used to fracture the rock.
There are environmental concerns about hydraulic fracturing in the Marcellus Shale, in part because the shales surrounding and including the Marcellus have already experienced natural fracturing, or jointing, as a part of their geologic history. It has been suggested that stimulating the Marcellus with hydraulic fracturing may cause the pre-existing fractures to connect and create a pathway that leads drilling mud, hydraulic fracture fluid, formation water, and methane gas to drinking water aquifers or water sources.

The Role of Hydraulic Fracturing

At present, hydraulically fracturing a well requires 3-5 million gallons of water, mixed with sand grains of different sizes and a number of chemicals, to be pushed into the rock at very high pressures. The chemicals perform various functions in the fracturing process, like killing bacteria and reducing the viscosity of the hydraulic fracturing fluid. While some of the chemicals are considered benign, others can be considered toxic: even when diluted with the large quantities of water used in the process. The fluid is injected into the well, and when the pressure of the fracturing fluid exceeds the pressure of the rock at depth, the rock breaks at weak points, usually along planes of weakness. The direction of these planes of weakness can be predicted to some extent based on the physical characteristics of the rock and the orientation of stresses the rock is under. During a hydraulic fracture, the rock breaks, creating fractures, or joints, which would, without something to prop them open, naturally close when the water pressure is subsequently lowered. The sand or sand-like grains in the fracturing fluid act as propping agents (prop-pants) remaining in the joints after the water is removed and the pressure is lowered to keep the joint networks open for natural gas extraction.

In sum, hydraulic fracturing
operates to open and maintain pathways for fluid to flow where it otherwise could not, and the process uses chemicals that would be unsafe if they entered drinking water aquifers or streams. If hydraulic fracturing were conducted near drinking water aquifers or if the induced fractures were sufficiently long or connected to long natural fractures, it is conceivable that the process could also connect new fracture networks with pre-existing ones to create a pathway for the natural gas, and the water and chemicals used to release the gas, to flow into drinking water aquifers. Finally, there are other substances trapped in the rocks around the Marcellus Shale, like brines and natural gas, which could contaminate drinking water aquifers if a pathway was created during the hydraulic fracturing process. For these reasons, it is important to understand how the naturally occurring joints and the fractures stimulated by oil and gas companies could interact in order to assess the risk of drinking water contamination in areas where drilling is done.

Natural Fractures

The Marcellus Shale is a naturally fractured rock because of the combination of the quantity of organic matter trapped in the rock and the historical plate tectonic activity that occurred in the area. The conversion from organic material to natural gas in the Marcellus created pressure in the fluids trapped in the rocks, which helped create natural fractures in the rock, called joints. These joints were further exacerbated by the collision of plates during the Alleghanian Orogeny, a mountain-building event that began around 350 million years ago. This combination of forces created the majority of the joints in the Marcellus Shale. Because the joints were formed from the same processes, most of the joints in the Marcellus Shale run in roughly parallel “sets” in one of two directions.

These two sets of joints are called J1 and J2, and each has unique characteristics. Joints in the J1 set run generally north-northwest and cuts across the J1 joint set. The J1 joint set happens to coincide with the modern underground stresses found throughout the Northeast. Joints in the J1 joint set are spaced more closely together than those in the J2 joint set. Joints in the J2 set are more likely to have been healed, which means the joint has been filled in with minerals and is no longer a pathway for gas flow. These healed joints are still relatively weak because the mineral cement gluing them together is weaker than the original bedding planes of the rock, and are therefore places where new fractures could grow.

In addition, the Marcellus Shale was buried by numerous other rock layers in the last 400 million years, some of which have been eroded since the Alleghanian Orogeny (in part by the numerous glaciations that have sculpted the current landscape of the Northeast). These erosional forces have brought the Marcellus Shale closer to the surface of the Earth and thereby decreased the downward pressure provided by overlying rocks. As overlying weight that had compressed the ground was released, much like a memory foam mattress, the decrease in pressure resulted in the J3 joint set. They, too, run roughly parallel, and are referred to as release joints and unloading joints.

Release and unloading joints created by the various unloading of rock and ice are only present at or near Earth’s surface. This is why J3 joints are not found at the depth of Marcellus Shale natural gas extraction.

How Stimulated Hydraulic Fractures Form

Hydraulic fractures form when the fluid pressure within the rock unit exceeds the external pressures pushing on the rock unit. To understand how hydraulic fractures could propagate (be “stimulated”) in Marcellus Shale natural gas drilling, drilling engineers must understand the pressures acting upon the rock.

Beneath the surface, there is vertical pressure from the weight of the overlying rock. There are also horizontal pressures in all directions pressing on the Marcellus Shale. These pressures are the result of plate tectonic forces interacting. The Earth’s outer shell is made of very large plates, like puzzle pieces, which slowly jostle each other. The interactions of these plates can build mountains and cause earthquakes, but in the Marcellus Shale region, they are weaker than the vertical pressure caused by the weight of the overlying rocks. Hydraulic fractures grow perpendicular to the direction (the plane) of minimum principle stress. In the Marcellus Shale region, fractures made by hydraulic fracturing at depth will have a vertical orientation.
and will separate against the minimum horizontal stress.

Because the vertical stress changes with depth, the orientation of the hydraulic fractures also changes as the fractures move closer to the surface. In sufficiently shallow rock, the direction fractures propagate can leave the vertical plane and propagate on an angle and could even approach the horizontal plane. So as fractures propagate into shallower rock above, they become less likely to propagate vertically and more likely to extend laterally into the rock. The depth at which this occurs varies by rock type and thickness and by the change in related pressures and is difficult to estimate.

While much of the Devonian rock surrounding the Marcellus Shale is also shale, there are many layers of silt, limestone, and sandstone, as well. Even the different shales surrounding the Marcellus are unique in their composition. These different kinds of rock layers are called lithologies, and each lithology has its own unique set of physical characteristics that react differently to the pressures that cause hydraulic fractures. Each lithology has been deposited under slightly different marine and terrestrial conditions, which can affect its grain size and provenance (where the grains came from and what types of grains are present), composition of the mineral glue cementing grains together, and the quantity of organics present in the shale. For example, some layers contain evidence of hurricane-force storms, and others record times of little or no sediment deposition. Some shales are black due to a high quantity of organic material, while others with less organic material are grey. The depositional conditions determine the physical characteristics of the lithology and thus how it may react to hydraulic fracturing. In general, limestones have higher fracture thresholds than shales and can act as barriers to vertical fracture growth.

As a fracture grows above or below the Marcellus Shale, it encounters other lithologies, and this can play an important role in determining the ultimate extent of a hydraulic fracture. Lithologies often change abruptly, representing events or changing environments in Earth history; such distinct boundaries between lithologies are often more weakly cemented together than the layers, or beds, within each lithology.

The stiffness of the Marcellus Shale is not uniform, so some areas are more prone to longer fractures than others.
Relatively highly fractured rock

Minimum principal stress

Relatively unfractured rock

1 2 3 3a

1

2

3

3a

Field geologists commonly note that a set of fractures end at a boundary between two lithologies, and sometimes use this characteristic to orient themselves at a new outcrop.

Hydraulic fracture characteristics are dramatically impacted by the measure of the modulus (ratio of stress to strain) of the rock. If the modulus is large, the rock is considered stiff. In stiff rock units, fractures grow long and narrow away from the source of additional pressure, and in less stiff materials, fractures are wider and vertically shorter because the pressures causing the fractures can penetrate and dissipate further laterally (into planes of weakness like bedding planes and existing fractures) within the rock unit. Shales are usually very stiff, but highly fractured black shales, like the Marcellus, are generally much less stiff than unfractured grey shales. The stiffness of the Marcellus Shale is not uniform, so some areas are more prone to longer fractures than others. However, when a hydraulic fracture hits the less stiff, already fractured materials in the Marcellus Shale, the energy can move laterally within the shale and, as a result, cause shorter, wider fractures.4,5,6

Understanding Current Fracture Networks within the Marcellus Shale

The Marcellus Shale is a naturally-fractured gas shale, and the body of literature on the characteristics of those fractures is expected to grow significantly as additional data are gathered. In some respects, the only way to gather additional data is to drill more wells and examine rock carefully removed from the well (a process called core sampling), so some things could remain unknown until after additional drilling has taken place. While this pamphlet highlights much of the base level understanding of Marcellus Shale jointing, some generalizations will be refined only after engineers have collected and analyzed data from numerous wells and core samples throughout the Marcellus.

There are a number of physical...
characteristics of the Marcellus Shale that are not homogeneous. For example, some geologists have hypothesized that the lower part of the Marcellus Shale, sometimes called the Union Springs shale, which has a higher organic content and larger quantities of pyrite (fool’s gold) than the rest of the Marcellus, may have more jointing (as a result of the maturing organics in concert with the Alleghanian orogeny). It would thus have a higher natural interconnection of fractures through which gas can move and a higher natural gas yield. Because the eastern part of the Marcellus Shale has been subjected to greater plate tectonic forces, jointing may be more abundant in the east. But thinner units are generally more fractured than thicker units, and the Marcellus is thinner in the west than it is in the east, so jointing could be hypothesized to be more prevalent in the western portion of the Marcellus Shale.6

The Marcellus Shale is the base rock unit in a group of shales and limestones called the Hamilton Group. The Hamilton Group is well known in New York State for the abundant fossils present in some of the rock units. While the Marcellus is not the only shale in the Hamilton Group, it is the only uniformly thick, gas-bearing, black shale. Black shales have some unique distinctions over grey shales, including a higher quantity of organic material and a higher amount of naturally-occurring radioactive material. Because of the organic content of black shales, the number of joints in a square unit of rock (joint density) is usually much higher than in grey, lower organic content shales, with spacing usually less than one meter apart in black shales.7 Because of this and other shale characteristics, many times the fractures in black shales consistently tend not to extend beyond lithologic boundaries into overlying (or underlying) grey shales.

The Marcellus Shale represents a dynamic system that has been changing for almost 400 million years. While there is consensus on basic fracture patterns likely to occur in the Marcellus Shale as a result of stimulation, the shale is not homogeneous, and different regions will react differently to the same hydraulic fracturing treatment. There will be areas with concentrated fractures and areas almost devoid of them, and while we can predict where those might be based on our understanding of how fractures form, there is not yet much observational data to support those predictions.

Tracking the Results of Hydraulic Fracturing

Because hydraulic fracturing is occurring beneath Earth’s surface, the only way to track fractures resulting from a hydraulic fracture is to use proxy evidence in the form of models, field tests, and monitoring production of wells, and incorporating that information into a body of knowledge that grows as more wells are drilled in the Marcellus region.

**Modeling**

Models are used to predict the effectiveness of hydraulically fracturing wells in shale gas layers like the Marcellus, and to inform future hydraulic fracturing in nearby wells. These models are based on data gathered in the field which are imported into software programs to predict the characteristics of the rock at depth. Field data usually incorporated into hydraulic fracture models include seismic and microseismic data, well log data, expected pressures throughout the subsurface, and other rock characteristics. Models predict how fracture fluid (and the associated pressures and fractures already present in the rock) will act during hydraulic fracturing. When measured values differ significantly from the modeled values, the fluids are not behaving in the way the model predicted they would and one or more characteristics of the rock have not been adequately modeled. This may occur if the model itself needs to be revised or if estimates of rock proper-
ties where the hydraulic fracturing is done were not accurate. Thus, to understand what is happening in the rock below the surface, modeling is used in concert with field testing to assess most effective hydraulic fracturing treatment for different regions in the Marcellus Shale.8,9,10

**FIELD TESTS**

Common field tests used initially to inform and eventually to truth fracture propagation models include observing well logs, seismic testing, sonic logs, gamma ray logs, resistivity logs, and monitoring fluid injection and downhole pressures of the well during hydraulic fracturing, among other techniques.11 Seismic testing is a technique that can be run on the surface of the Earth, but most techniques require an observational well to be drilled for monitoring purposes. A few field techniques will be discussed below.

Seismic testing uses seismic waves, created by ‘thumping’ the ground with heavy weights, to read the subsurface. The waves travel through the ground, hit different layers of rock, fractured zones, and other variations in density beneath the surface of the Earth, and return to the surface at different times. The waves are recorded and analyzed to create an image of the rock layers beneath the surface. These tests are usually run along roads or other straight paths, and interpreted with other seismic tests to search for existing fractures and other structures in the subsurface that could potentially interact with a hydraulic fracturing treatment. Because seismic testing can be done from Earth’s surface, it is sometimes used after hydraulic fracturing to explore the accuracy of the model of fracturing in predicting actual fracture patterns.

Microseismic testing works in much the same way as seismic testing, but small seismic monitors are placed at the surface, or shallowly buried, above the area undergoing hydraulic fracturing. These monitors record small seismic changes and relay them, frequently in real time, to the engineers conducting the hydraulic fracturing treatment. This is the most effective way to visualize the fractures that are created during a hydraulic fracturing and evaluate model effectiveness.12

Well logs are descriptions of the rock layers as observed by the drillers that document the rock type, jointing, and other visual characteristics of the rock. Sonic logs are similar in principle to seismic tests, but use sonic waves instead of sound waves. Also, sonic logs are run down a well so that, instead of from the surface, the sonic logs record information near the well bore. Gamma ray logs also run down the well bore, but these look specifically for natural radioactivity, which is much higher in black shales than in other rocks. Gamma ray logs help drillers determine the thickness and depth of the reservoir rock in the region. Resistivity logs use various methods to extract the porosity and fluid content of different rock layers.

Observation wells are sometimes drilled near a well undergoing hydraulic fracturing while a region is being established to collect data on the effectiveness of hydraulic fracturing. A similar suite of field tests and observations can be conducted on an observation well to more objectively test the effectiveness of a hydraulic fracturing treatment, the model used to predict the fracture behavior, and other parameters.13,14

**Existing Fracture Networks**

Natural gas has been rising toward areas of low pressure since it formed in the Marcellus Shale, which is part of the reason for the existing fractures in the unit. Natural gas has reached near-surface layers along fracture networks where the Marcellus Shale (and other shales and limestones) comes within several hundred feet of the surface. Some of these seeps were sources for natural gas for towns during the 19th century. This is why methane can also be found rising from some abandoned, uncapped wells.

The NYS DEC has recommended that stimulation more than 2,000 feet beneath the surface is deep enough to avoid impacts on potable water sources.15 Fluid and gas migration through fracture networks from below 2,000 feet to the surface is not theoretically impossible. A recent study documented the presence of thermogenic gas in water wells within close proximity of active gas wells.16 Thermogenic gas, the kind of gas found in the Marcellus Shale, is the result of temperature and pressure changes deep beneath Earth’s surface that change carbon matter into methane. It has a different chemical signature than biogenic natural gas, which is produced by the metabolic decay of organisms close to Earth’s surface. This study correlates a high percentage of thermogenic gas (as opposed to a mix of thermogenic and biogenic gas) contamination with ac-
Conventional oil and gas drilling has occurred in NY and throughout the northeast. The only type of drilling that has occurred in surrounding networks, it is also important to note that existing fracture networks have not allowed these substances to escape.

The study also noted that some water wells that were not located near active gas wells had methane contamination. However, the amount of methane in these wells was far less than those water wells near active gas drilling, and the chemical makeup of the methane was a mix of thermogenic and biogenic natural gas. The reason gas and other fluids may migrate from fractures near the surface—leaving a small amount of mixed methane contamination—but not from a mile beneath the surface is likely related to the number of rock units acting as barriers to migration and the degree of discontinuous fractures passing from the Marcellus to the surface.

In considering existing fracture networks, it is also important to note that Marcellus Shale drilling is not the only type of drilling that has occurred in NY and throughout the northeast. Conventional oil and gas drilling has commonly occurred throughout NY for decades, and some of these wells were improperly abandoned. At least 70,000 wells have been drilled in NYS and only 30,000 are accounted for by the DEC.

When a well is no longer producing commercial quantities of oil or natural gas, a company abandons the well. Abandoning a well properly involves removing some of the casing and other surface equipment, plugging the well with cement so that it is no longer a conduit for fluids migrating from beneath the surface, and then reclaiming the surface. If wells are improperly abandoned, they can act as a connection between the surface and the depth of the well. In most cases, improperly abandoned wells are older and relatively shallow, but when the Marcellus Shale is being exploited at shallower depths, like in central NY, improperly abandoned wells could potentially connect a fracture network to a groundwater source. Improperly abandoned wells were considered when the DEC suggested that stimulation of Marcellus Shale should be at least 3,000 feet beneath the surface to sufficiently decrease risk of contamination of potential groundwater sources.

Fracture networks are not the only consideration of how fluids can travel through rock layers to the surface. Because of the greater pressures beneath the surface, fluid naturally flows toward areas of lower pressure if a pathway (through fractures or between connected pore spaces) exists. Permeability (amount of connected pore space) is measured in milliDarcies (after Darcy's Law, which describes how fluids flow through porous media). The rate at which a fluid can flow through a rock, based on the amount of fluid present, pressure, fracture presence, and rock permeability, is called conductivity.

The conductivity of the Marcellus Shale is relatively low, but varies between 0.000011 and 0.00059 feet per day (just over 7/1000th of an inch of movement per day at its fastest), and the surrounding units also have variable but low conductivities. It is more common for fluid to flow horizontally than vertically in the Marcellus Shale because of the pressures at depth and the existence of horizontal bedding planes. However, it is not impossible for pressures at depth to create a gradient angled to some degree toward Earth's surface in some regions of the Marcellus or surrounding units. As the rock unit changes, the direction of flow and conductivity can change.

Very little data is available on the range of conductivities in the rocks surrounding and including the Marcellus Shale in locations being examined for natural gas drilling, although more is gathered by gas companies as additional wells are drilled. The impacts of the short-term increase in pressure caused by hydraulic fracturing conductivity from the depth of the Marcellus Shale to the surface is not well understood, and could possibly play a role in the migration of gas and fracture fluids to adjacent rock units although are not likely to provide sufficient pressure change to migrate gas and fracture fluids all the way into drinking water aquifers.

The conductivity of the Marcellus Shale and its overlying units does not currently allow significant methane migration from depths being considered for natural gas extraction to the surface. If that were the case,
the quantity of natural gas stored throughout the Marcellus Shale would have been greatly diminished by now. We might assume, therefore, that the conductivity provided by existing fracture networks connecting the Marcellus to much shallower units is very low. Based on this reasoning, it appears unlikely, though not theoretically impossible, that gas and fracture fluid could migrate to potential sources of drinking water in this way.

Although it is expected that hydraulic fractures would propagate upward little further than the top of the Marcellus, one ought to consider the potential impact if there were sufficient pressure from hydrofracturing to connect to and open existing fractures up to very shallow depths, or to connect them with shallow, improperly abandoned wells. Fractures remain open during pressurization from hydrofracturing, for a few hours at a time for up to a few days, then remain open if proppant sand has entered the fractures. If fractures did connect to existing fracture networks, they would not have sufficient proppant to keep them open after hydra-

<table>
<thead>
<tr>
<th>Rock Characteristics</th>
<th>Coal Bed Methane Extraction</th>
<th>Marcellus Shale Methane Extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>depth below surface</td>
<td>0–6,000 ft; most between 400–4,000 ft</td>
<td>3,000–10,000 ft</td>
</tr>
<tr>
<td>Aquifer location</td>
<td>mostly within 450 ft</td>
<td>0–1,000 ft (most less than 700 ft)</td>
</tr>
<tr>
<td>Surrounding rock lithologies</td>
<td>variable; other coal seams, shale, sandstone</td>
<td>mostly shale, some silt and limestone lenses; varies regionally</td>
</tr>
<tr>
<td>Thickness of desired unit</td>
<td>inches to 250 ft thick lenses</td>
<td>one contiguous layer between 50–250 ft thick; regionally variable</td>
</tr>
<tr>
<td>Original deposition of rock unit</td>
<td>in terrestrial settings, among braided streams, wetlands, and deltas</td>
<td>bottom of shallow, continental sea</td>
</tr>
<tr>
<td>Depth of targeted formations for hydraulic fracturing</td>
<td>0–6,000 ft; dependent upon target depth</td>
<td>3,000–10,000 ft; dependent upon depth of unit</td>
</tr>
<tr>
<td>Pre-existing fractures in desired rock unit</td>
<td>cleating present; degree of cleating primarily based on coal type and depth below surface</td>
<td>fractures present; degree of fracturing based on organic content, rock unit thickness, and proximity to tectonic action; varies regionally</td>
</tr>
</tbody>
</table>

Comparison of the geological characteristics of coal bed methane extraction and Marcellus Shale methane extraction. Coal bed information compiled from data from Powder River, San Juan, Raton, Piceance, and Uinta Basins. Marcellus Shale information from Hill, et. al., 2002.
lic fracturing was complete. To date
migration through such fractures of
fracturing fluids and produced water
has not been documented. This may
be because such vertical migration
paths do not or rarely exist, or be-
cause the amount of fracturing fluid
and proppant that can migrate verti-
cally over such a distance is small.

**Understanding Fracture Networks in Different Rock Units**

Different rock types, like sand-
stones, shales, and coal seams, have
different physical characteristics that
impact the likelihood of the ability of
fractures to grow upward toward the
surface from various depths. When
they are sought after for fossil fuel
extraction, the depth of the rock unit
below the surface, the stiffness of the
rock unit being targeted and of the
surrounding lithologies, the regional
stresses on the rocks, the depth of po-
table water, and many other consid-
ertions are used to predict the impact
hydraulic fracturing will have on a
particular lithology.

Recently, water well contamina-
tion in coal bed methane extraction
using hydraulic fracturing has been
used to compare the potential for
water well contamination in the
Marcellus Shale. It is important to
learn from the environmental prob-
lems experienced in other active gas
plays; comparisons among different
reservoir rocks, however, must also
consider the important geologic
similarities and differences between
them.

While the organics in the Mar-
cellus Shale were deposited at the
bottom of a shallow sea basin and
were comprised primarily of marine
algae, coal beds are deposited in ter-
restrial environments and are usually
comprised of woody and leafy plant
matter. Coals generally form around
braided streams, wetlands, or delta
environments, and, as a result, an in-
dividual coal layer usually cannot be
traced laterally for a long distance. In-
stead, the environment conducive to
col formation moves and migrates,
like sand bars in a stream. The result
is that a coal bed can sometimes be a
series of horizontal lenses interspersed
in a vertical unit of rock. Coal can
also form in one distinct layer, but
even then the thickness of the coal is
highly variable. Coal deposits usually
have a much smaller regional extent
than the Marcellus Shale. This is be-
cause they are deposited in areas near
streams, lakes, and rivers, which are
geographically smaller than shallow
continental seas.

As a result of these geologic dif-
fferences, the target depth for coal bed
methane extraction extends from very
shallow depths that sometimes inter-
sect drinking water aquifers to depths
that are similar to those for Marcellus
Shale gas drilling. The target depth
for gas extraction has a narrow range,
changing vertically—at most—around
500 ft. in a 25 mile radius. However,
in a coal bed over the same 25 mile
radius, the target depth for methane
extraction can range from around
400 to 4,000 feet, and multiple
depths may be targeted. Shallow coal
beds (less than 450 ft deep) are not
only home to sources of methane, but
sometimes are the source of potential
drinking water.

Shallowly buried coal is usually
highly permeable, because as the
organic material matures fractures
form called cleats, which cause mined
coal to appear blocky. Cleats increase
col permeability dramatically. This
is why fresh water can frequently
be found in shallow coal beds, and
why coal bed methane extraction
frequently involves what is called
“dewatering the coal.” This is also
why methane can flow easily within
the coal, especially at shallow depths.
When coal is more deeply buried,
however, the pressure of the overlying
rocks can close the cleats and lower
the permeability of the coal. Natural
gas companies prefer to extract gas
from shallower coal units because
of this. Because coal bed methane is
sought from a wide range of depths,
and because coals have a higher per-
meability, stimulated fractures are
usually intended to connect between
multiple coal layers.

Some similarities can be drawn
between coal bed methane extraction
and Marcellus Shale methane extrac-
tion, but in detail, the similarities are
few. Because of the different physical
characteristics that dictate how and
where natural gas is stored in the rock
types, the permeability of the rock
units, and their proximity to poten-
tial drinking water sources, the likeli-
hood of fractures propagating beyond
their target zone(s) in coal bed meth-
ane extraction is much higher than in
the Marcellus Shale.

**Summary**

There has been significant com-
munity concern that high volume
hydraulic fracturing of the Marcellus
Shale may allow fluids—including
natural gas—to rise from connected
fracture networks several thousands
of feet below aquifers. In addition,
the Marcellus Shale has been deeply fractured by several geologic events since deposition of the shale. Where the Marcellus Shale occurs near the surface, for example in western New York, natural gas has been known to seep naturally into drinking water aquifers and to the surface. Available evidence suggests that deep shale (several thousand feet) is not naturally connected to drinking water sources through fracture networks, likely because of the discontinuity of fractures across numerous lithologies. It is not known to be impossible for fluids to migrate to drinking water sources from deep hydraulic fracturing, but the likelihood of significant migration appears to be very low, especially when compared to the risk of faulty casings or surface spills as a potential source of contamination. Finally, the relative risk of hydraulic fracturing varies substantially by local geological context, including the nature and depth of source rock, lithology of overlying rocks, and the nature of existing fractures and fault networks. Any comparison between the Marcellus Shale and another source of natural gas must be well framed and consider these parameters.

References


7. Sankaran, S., M. Nikolaou, and M.J. Economides, 2000, Fracture Geometry and Vertical Migration in Multilayered Formations from Inclined Wells, SPE 63177, 8 pp.


