Appalachian Spring

A new shale play emerges in the East
Marcellus Shale 101

1. What is the Marcellus Shale?

2. Where is the Marcellus Shale?

3. What’s all the fuss about?
1. What is the Marcellus Shale?

...Devonian (385 million years old) black shale...
385 million years

Laurentia

Gondwana (Africa)

1. subtropical climate
2. plate tectonics

...becoming a hydrocarbon source rock...
Devonian - extremely warm period of Earth’s history...

1. abnormally warm climate (layered ocean);
2. prevents oxygen from reaching the bottom (cooler) water;
3. the bottom water is quickly depleted of oxygen as a consequence of the abundant organic remains of plankton sinking through the water;

a warming climate favors the preservation of organic remains
transformation of organic remains to oil and natural gas...

...heat...

oil window

gas window

<table>
<thead>
<tr>
<th>Oil/gas window</th>
<th>Depth (km)</th>
<th>Temp (°C)</th>
<th>Vitrinite Reflection</th>
<th>Subsurface process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerogen</td>
<td>1</td>
<td>30°C</td>
<td></td>
<td>Diagenesis</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>60°C</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>3</td>
<td>90°C</td>
<td></td>
<td>Katagenesis</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>120°C</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>5</td>
<td>150°C</td>
<td>2.0</td>
<td>Metagenesis</td>
</tr>
</tbody>
</table>

HC generation
Laurentia burial and thermal maturation of the Marcellus Shale 300 million years forming Appalachian Mountain belt

Gondwana (Africa)

300 million years
2. Where is the Marcellus Shale?

...in the subsurface...
distribution of Marcellus Shale in Appalachian Basin

Milici, 2005
...finding the Marcellus Shale in the subsurface...

...geophysical well logs...

GR = gamma-ray logs; a measure of the natural radioactivity of the rock

Rho = density logs; can be used as a measure of the amount of organic matter in a rock
3. What's all the fuss about?
potential reserves

Distribution of Marcellus Shale in Appalachian Basin

50 tcf!

Milici, 2005
BTU 1 barrel of oil ~ BTU 6,000 ft\(^3\) of natural gas

18 July 2008 1 barrel of oil = $129
18 July 2008 1000 ft\(^3\) natural gas = $10.57

on this day, the cost of the BTU equivalent of natural gas of a barrel of oil ($129) was $63.42
technology

horizontal drilling and fraccing techniques

thickness of Marcellus drained by a vertical well

Well is turned horizontal

thickness of Marcellus drained by a horizontal well
Horizontal drilling can provide greater access with a smaller footprint

Multiple horizontal wells from a single drilling pad could drain 200 – 400 acres
technology

horizontal drilling and fracching techniques

Well is turned horizontal

Marcellus Shale

Hydrofrac Zone
technology

horizontal drilling and fraccing techniques

artificial hydraulic fracturing
Technology

Horizontal drilling and fraccing techniques

Artificial hydraulic fracturing

Hydraulic Fracturing

Hydraulic fracturing, or “fracking,” involves the injection of more than a million gallons of water, sand and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.
perforating (perfing) a tight (impermeable) reservoir rock
technology

horizontal drilling and **frac**ing techniques

artificial hydraulic fracturing

**proppant** - sand
dimensions of the Marcellus Shale play

core area of the Fort Worth Basin

Barnett Shale; Fort Worth Basin

Marcellus play

Marcellus > 50'
proximity to NE markets and a robust pipeline infrastructure economics

www.eia.doe.gov/.../ngpipeline/northeast.html
potential benefits...

- increased employment in exploration, operations, well services, and real estate;
- leasing and royalties flowing to landowners;
- pipelines (construction and maintenance);
- investment by producers;
- cooperate taxes;
Will it work?
first natural gas well - Fredonia, NY