Developing a New Gas Resource in the Heart of the Northeastern U.S. Market: New York’s Utica Shale Play*

John P. Martin\textsuperscript{1}, Richard Nyahay\textsuperscript{2}, James Leone\textsuperscript{2}, and Langhorne B. Smith\textsuperscript{2}

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Abstract

After significant research, industry is now investing in leasing, exploratory drilling and modern completion methods for the Utica Shale. When developed, this play will represent the easternmost natural gas field in the USA. The prospective fairway includes 17 counties bounded by the Hudson River, the Finger Lakes, the Mohawk Valley and the Pennsylvania border. The Utica is a massive, fossiliferous, organic-rich, thermally-mature black to gray-black shale deposited in a subsiding trough that generally trended north-south. Source rock for the organic-rich black shale was supplied from the eroding Taconic highlands to the east. As the deep marine trough filled, the deposition of the lower members of the group onlapped westward over the carbonate platform. The Dolgeville, interpreted as a slope facies peripheral to the Trenton platform, interfingers with the basal Flat Creek black shale Member. The Flat Creek Member thickens considerably in the eastern half of New York, whereas the uppermost Indian Castle Member spreads widely across the Appalachian Basin. The exploration fairway has been defined through an analysis of cuttings and cores defining unit properties, Rock-Eval parameters S2, Tmax, HI (Hydrogen Index), and TR (Transformation Ratio). Current work shows that the Utica has TOC values between 1.5 and 3, and with higher original TOC. Fairways have been defined using a TR of 0.95. S2 values are low, suggesting that little live carbon remains, and most of the gas that could be generated has been adsorbed into the matrix. Current drilling activity to date has concentrated on the shallower northern areas but technical evidence supports much deeper drilling depths. Hydraulic fracture designs include the use of acid to take advantage of the high calcite component. Since this play is within the eastern gas market, producers can expect a sales price premium over NYMEX.

John P. Martin¹, Richard Nyahay², James Leone³, Langhorne Smith³

¹ New York State Energy Research and Development Authority
² New York State Museum
Outline

• Shale is the **New Black**
• New York During the Ordovician
• Utica Geology
• Utica Shale Properties
• Utica Shale E&P
• Conclusions
Shale is the New Black

- New technology and practices make shale a viable drilling target for natural gas.
- Tightening North American supply is making “unconventional resources” more attractive.
- The Antrim and Barnett show, there is no one model for shale exploitation.

![Shale is the New Black](https://www.geo.utexas.edu/scientist/milliken/barnettshale.htm)

**Gas Production Mechanisms**

- Natural Fracture Network
- Desorption From Internal Surfaces
- Flow Through the Matrix
- Flow in the Natural Fracture Network

SOURCE: Ron McDonald, Schlumberger Data Services

**Stage 1**

**Stage 2**

**Stage 3**
Paleogeography of the Eastern United States During the Early Late Ordovician

Modified after Cornell (2003), www.mcz.harvard.edu/Departments/InvertPaleo/Trenton/Intro/GeologyPage/Geologic%
Trenton Shelf and Taconic Foredeep Basin

Utica Shale Stratigraphy
Extent of Ordovician Utica Shale
Flat Creek Member

- Transgressive deep basinal calcareous black shale (first mud flux)
- Pictures are from the towns of Fonda (left) and Florida, Montgomery Co.
Flat Creek member thickens to the southeast (all Utica data points shown)
Dolgeville Member

- “Pulse” carbonate/shale with turbidite attributes (slope facies) –
- Shale members resemble Flat Creek; limestone members resemble Denley Limestone (Trenton Group)

Utica/Shale/Dolgeville – West of Little Falls
Indian Castle Fm. (Utica Group)
Dolgeville Fm. (Trenton Group)

Asymmetrical slump fold in Dolgeville

Dolgeville thickens to southeast
**Indian Castle Member**

- Transgressive, fissile shale with some calcareous interbeds
- Upper (monotonous, fissile) and lower units (blocky with impure limestone beds)
Utica formation thickens to the east due to subsidence associated with the Taconic Orogeny.
White line – edge of Steuben Limestone & start of slope (Dolgeville)

Presenter’s Notes:
The Utica thickens to the east where the Flat Creek and Dolgeville are part or the formation. They cut out when the stuben limestone of the trenton appears in the west and thins the utica to just the indian castle member.
Utica Structure Contour Map

Utica gets deeper to the south
Utica Shale Properties

• Mineralogy
• Organic Content
• Thermal Maturity
• RockEval and Adsorption
• Fractures and Rock Fabric
### Sample Mineralogy: Volume % XRD

<table>
<thead>
<tr>
<th>Sample Mineralogy</th>
<th>Indian Castle</th>
<th>Flat Creek</th>
<th>Indian Castle</th>
<th>Indian Castle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>28.00%</td>
<td>9.80%</td>
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<td>K-Feldspar</td>
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<td>Plagioclase</td>
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<td>Calcite</td>
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<td>59.00%</td>
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<tr>
<td>Dolomite</td>
<td>5.40%</td>
<td>8.10%</td>
<td>6.50%</td>
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<tr>
<td>Pyrite</td>
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<td>0.40%</td>
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<tr>
<td>Illite &amp; Mica</td>
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<td>20.00%</td>
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<tr>
<td>Kaolinite</td>
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<td>0.00%</td>
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<tr>
<td>Chlorite</td>
<td>8.40%</td>
<td>0.00%</td>
<td>0.50%</td>
<td>0.90%</td>
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<tr>
<td>Total</td>
<td>100%</td>
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<table>
<thead>
<tr>
<th></th>
<th>Calculated Clay Volume</th>
<th>Calculated Grain Density</th>
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<tr>
<td></td>
<td>39%</td>
<td>2.73</td>
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<td></td>
<td>26%</td>
<td>2.71</td>
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<tr>
<td></td>
<td>27%</td>
<td>2.72</td>
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</table>
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

Type Log shows synthetic TOC derived from density log (pink >2%) (Meyers and Jenkins, 1992).

Upper Indian Castle: Siliceous Shale w/ dolomite
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

Type Log shows synthetic TOC derived from density log (pink >2%).

Lower Indian Castle: Calcareous Shale with varied thickness on limestone beds.
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

Type Log shows synthetic TOC derived from density log (pink >2%).

Dolgeville: rhythmic shale and limestone
Cross Plot: Flat Creek

Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.
Type Log shows synthetic TOC derived from density log (pink >2%).
Flat Creek: black calcareous shale
Cross Plot: Trenton Rust Member

Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.
Type Log shows synthetic TOC derived from density log (pink >2%).
Trenton Rust Member: silty limestone
Ternary Diagrams: Utica & Barnett

Flat Creek ★
Indian Castle ▼
Total Organic Content

TOC from Cuttings:

- Indian Castle < 1.5%
- Dolgeville 1.5 - 2.0%
- Flat Creek 2.0 – 4.0%
  (one point measured at 5%)

In Jarvie et al., 2005 study TOC from cuttings were 2.36 times lower than samples from core, therefore this same dilution effect would be seen on other geochemical parameters.
Gamma Ray Log & TOC measurements

- TOC measurements made on well cuttings, cores and outcrop
- Subtle shift in gamma ray curve is due to increased organic content
- TOC is increasing in basal part of Utica (Flat Creek)
- Repeatable gamma ray curve has changed character due to increased TOC
TOC increases to the SE as Utica (Flat Creek and Dolgeville members) also thickens in that direction
**Utica Kerogen Type from Cuttings, Unpreserved Core and Outcrop**

Difference between original potential and present-day potential is the amount of Hydrocarbons generated (Jarvie, 2007).

Data source: NYS Museum and Wallace and Roen, 1989
RockEval from Mohawk Valley Cores

• Results affected by the sampling method which chose the slightly siltier sections of unpreserved cores.
• Measured porosity 3-6%
• Ballpark est. showed 25% of gas stored in pore space; 75% adsorbed
• Oddity: mobile oil saturation up to 2.88% (one sample)

• “Successful gas production from the Utica may depend more on finding the reservoir at suitable depth with high enough pore pressure, than on the physical properties of the rock.” (Terratek report)
Adsorbed Gas Storage Potential of the Utica and Other Shales

Adsorption Methane Isotherm Various Shales

Laboratory methane isotherms for various shales in the U.S. for comparative purposes
• Note different experiment temperatures, and
• Different shale maturations as expressed by vitrinite reflectance

Presenter’s Notes:
This slide shows laboratory methane isotherms from various gas shale in the US. While the TOC values are in a similar range, the experimental temperature and vitrinite reflectance values are notably different. Gas storage by adsorption is inversely proportional to temperature. So for lower temperature experiments, gas storage is higher by adsorption for a given sample. Shale maturation as well as kerogen type will also have an effect on gas storage by adsorption.
In order to calculate this ratio, you need the present day Hydrogen index (HIpd) and original Hydrogen index (HIo) (see Jarvie et al., 2007 for formula)
Fracture Sets in Flat Creek Member
Indian Castle Rock Fabric: SEM Image

Outcrop sample from near bottom of Utica shows clay and silt-size quartz. Image taken by Neal O'Brien, SUNY Potsdam, 9/17/85.
"Low magnification, autofluorescent light view illustrating typical carbonate rich (pink) areas mixed with darker clay rich shale texture."

"Low magnification edge view of the porous shale sample showing a generally uniform texture with numerous, very small carbonate microfossils."

"Close-up of the microporous shale texture and thin, organic films. Carbonate dissolution has contributed to microporosity development."

"High magnification view showing detail of carbonate microfossils deposits mixed with microporous, soft marine clay particles."
Utica Shale Exploration and Production

- The Utica Shale is considered the source rock for the Silurian and deeper hydrocarbon fields in the Appalachian Basin.
- The Utica has had shows in over 40% of the TBR wells.
- The historic “Upper Trenton” gas fields of New York are now considered Trenton/Utica shale producers (date back to the 1880s).
- Drilling in Quebec indicates Utica potential (e.g. Soquip [1970s], GASTEM, JUNEX, Questerre, Forest Oil).
- The Pointe du Lac Field, Quebec (Quaternary age!) partially sourced by the underlying Utica.
- Two new wells in New York have been drilled targeting the Utica.
Shallow “Trenton” Play

- The typical well has several very high pressure gas shows.
- The gas will flow at a high rate for a few hours or days and then drop off to a very low rate of ~10 mcfd.
- It will flow at this rate for decades.
- Drilling practice was to drain high-rate producing intervals and then drill deeper.
- A few wells have sustained higher rates for longer periods of time (probably vertical fracturing near faults).
“That the gas is confined to the shale partings and shale layers can be observed at any well during the drilling of the Trenton. The drill first strikes a hard, dense limestone layer which is usually only a few inches thick but is hard to penetrate. As the drill breaks through this layer the gas rushes forth, sometimes under enormous pressure which may even blow the tools out of the hole. When drilling is again resumed it is invariably found that the layer under the hard dense limestone is a calcareous shale …No increase in volume is realized until another hard dense limestone is reached. Unquestionably the limestone acts as a cap rock.” - Gillette, 1935
Bender Gas Well Contacted Powerful Gas Pocket at One O'clock This Morning

The Bender gas well, which is being drilled on the Harvey Dutt farm near this village, struck a pocket of gas this morning at 7 a.m. A shock that echoed for miles indicated the existence of a rich gas deposit. The gas release is estimated to be approximately 2 million cubic feet per day.

The young miner who came to work at 7 a.m. has been working on the well since 4 a.m. today. The gas pressure was strong, and the workers had to operate the machinery with caution. The gas was escaping at a rate of 120,000 cubic feet per hour.

The operation has been suspended temporarily to allow the gas to be collected and the machinery to be adjusted. The gas will be used by local businesses and will contribute to the local economy.

Gusher Blows in at 10:15 Today

As the last forms of the advance operation have been completed, the gas pool has exploded, and a gusher has blown in at 10:15 today. The gas, which is being collected for industrial use, has been a disappointment to the local community, which was expecting a major finding.

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Explosion Skyrockets Two Ton Drill, Disrupts Cable and Fires Rock to Top of Derrick-Work Proceeds for a Main Vein.

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Forest Oil Announces Shale Gas Discovery In Quebec

By Pat Roche, Daily Oil Bulletin

Denver-based Forest Oil Corporation today announced what it termed a "significant" natural gas discovery in the Utica Shale in Quebec.

[paragraph deleted]

Forest said two vertical pilot wells were drilled to a total depth of 4,800 feet in 2007 to test the Utica Shale. Production rates tested up to one mmcf equivalent a day, the company said.

Quebec new natural gas hot spot

David Pett, Financial Post Published: Friday, April 11, 2008

Quebec is all of a sudden the hot spot for natural gas exploration in Canada and based on another massive surge in stock prices yesterday from the province's shale gas explorers, it appears investors may just be getting warmed up.

Interest in Quebec's Utica Shale natural gas play caught fire last week..
## Comparison of Shale Rock Properties

<table>
<thead>
<tr>
<th></th>
<th>Barnett</th>
<th>Utica-Quebec</th>
<th>Utica-New York</th>
<th>Marcellus-New York</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depth (ft)</strong></td>
<td>4,500-9,000</td>
<td>2,300-8,000</td>
<td>0-12,000</td>
<td>0-16,000</td>
</tr>
<tr>
<td><strong>Thickness (ft)</strong></td>
<td>150-700</td>
<td>500</td>
<td>300-1,200</td>
<td>100-1,300</td>
</tr>
<tr>
<td><strong>Clay Content (%)</strong></td>
<td>15-30</td>
<td>15-26</td>
<td>20-27</td>
<td>11-49</td>
</tr>
<tr>
<td><strong>TOC (%)</strong></td>
<td>3.5-5.0</td>
<td>1.0-3.1</td>
<td>11.0-15.0</td>
<td>11.5-12.0</td>
</tr>
<tr>
<td><strong>Porosity (%)</strong></td>
<td>3.0-4.8</td>
<td>3.2-3.7</td>
<td>4.3-5.45</td>
<td>Est. 0.5-2.5</td>
</tr>
<tr>
<td><strong>Pressure (psi/ft)</strong></td>
<td>40-50</td>
<td>45-60</td>
<td>Est. 20-30</td>
<td>Est. 0.125-1.4</td>
</tr>
<tr>
<td><strong>Maturity (R0)</strong></td>
<td>1.0-2.2</td>
<td>1.5-2.9</td>
<td>1.6-2.3</td>
<td>0.5-3.0</td>
</tr>
</tbody>
</table>

Source: Barnett, Utica-Quebec: Forest oil presentation April 2008. New York data: NYSERDA, NYSM (some data taken from other sources)
And the Hype Has Moved to NYS

New York to get Utica shale exploration


Gastem will earn a 65% working interest in all 29,000 acres of leases held by Utica Energy and in other leases that may be obtained during the year. Drilling is to start in the second quarter subject to permitting and other approvals. The companies declined to identify the location more precisely. Gastem’s program will target gas in the Upper Ordovician Utica shale formation, already the object of exploration on Gastem’s Yamaska property west of Drummondville, Que., in the St. Lawrence lowlands.

Utica Energy drilled, completed, and ran frac jobs on two test wells on its acreage in mid-2007. Other intervals identified during logging, notably the Devonian Marcellus shale, will also be tested for gas potential. The acreage is near gas pipelines.
And Some Hype is Self-Induced…

From Gas Daily 4/7/08

**Geologist details burgeoning New York shale play**
America’s next big shale play lies just to the east of the first shale gas well ever dug in the country and just to the west of gas-hungry New York City, a geologist for the state said Friday.

A large portion of central New York offers producers the chance to drill into both the Marcellus and Utica shales from the same leasehold — the two overlap in 80% of a triangular fairway defined by Albany to the east, Syracuse to the north and Corning to the west, John Martin said. (by Bill Holland)
Yes, 2 for the (Land) Price of 1

- The Utica and Marcellus fairways* in New York are considerable.
- The fairways overlap with the Marcellus, offering a “2 for 1” opportunity.
- An active conventional sandstone gas play also exists in the region (3 for 1?)

* Transformation ratio > 0.95
Conclusions

• The Utica of NY offers a resource play within a day’s trip of the City of New York.
• The Utica can now be defined in the subsurface from geophysical-wireline logs.
• TOC ranges define different members of the Utica but is highest TOC is in Flat Creek.
• New York offers a 2-for-1 shale opportunity
• Data on NY can be found at “ESOGIS.”
Acknowledgements

The authors like to thank Dan Billman (Billman Geological Consultants), Jay Leonard (Platte River Associates), Denis Lavoie (Commission géologique du Canada), John Keller (Terratek), David Hill (EnCana), Dan Jarvie (Worldwide Geochemistry), Fortuna Energy, and EOG Resources.

Historical Note

In 1821, the first shale well in the United States was dug into the Dunkirk Shale in Fredonia, Chautauqua County, New York. The Hart Well, originally 27 feet and deepened to 70 feet, was drilled at the site of a gas seep. General Lafayette, on his final tour of the United States, visited Fredonia on June 4, 1825 and witnessed the only street in the world lit by natural gas. The well produced until 1858.