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

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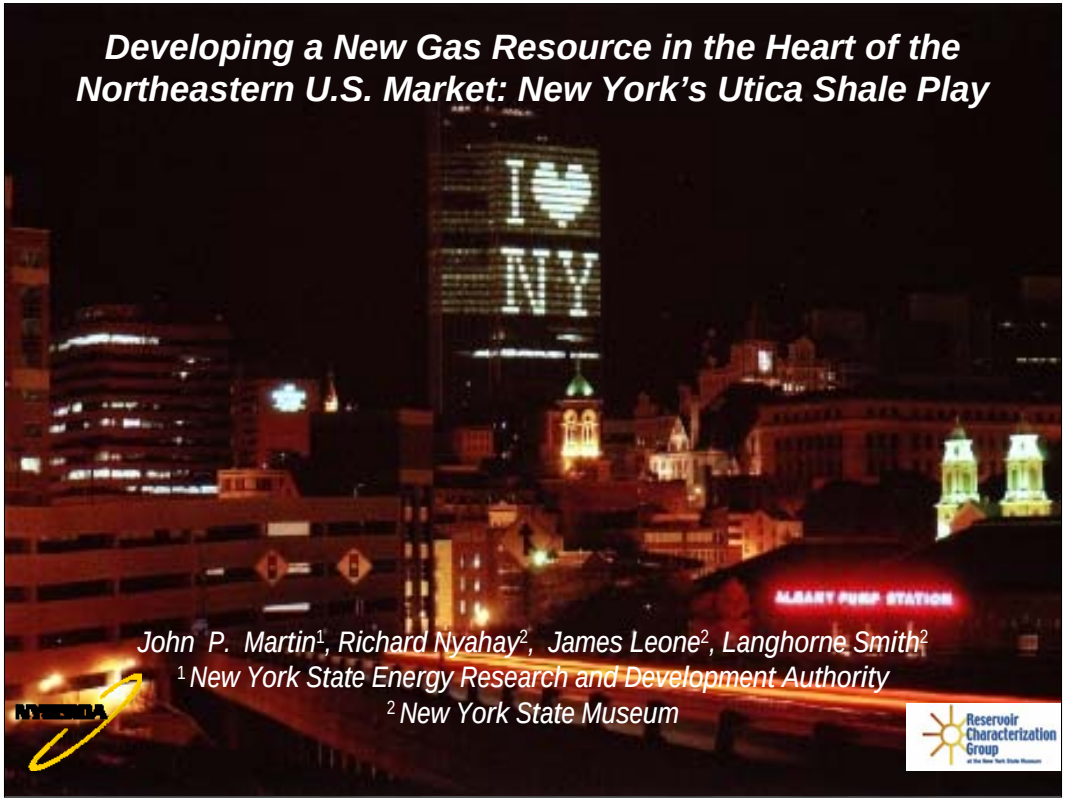
Abstract

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.

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



John P. Martin[1], Richard Nyahay[2], James Leone[2], Langhorne Smith[2]

[1] New York State Energy Research and Development Authority

[2] New York State Museum

Reservoir Characterization Group

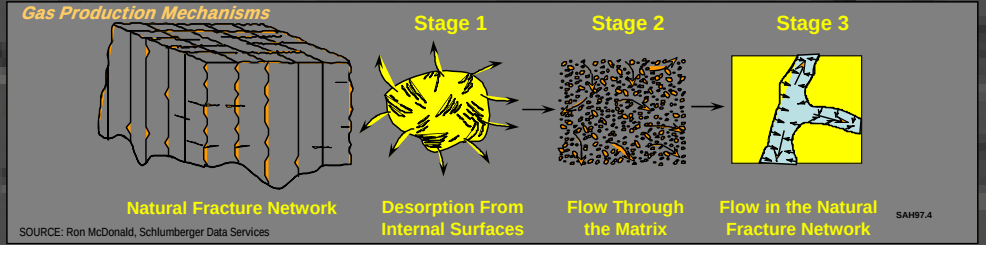
Outline

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

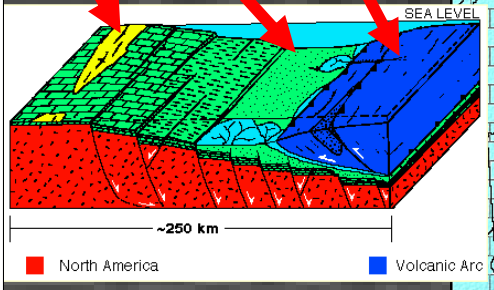
Shale is the New Black

- 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.

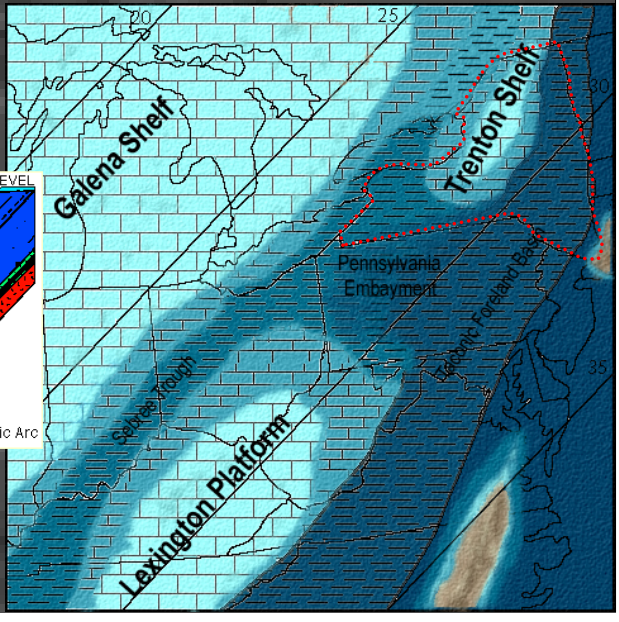
Photo of the Barnett Shale at the J. R. Walker Ranch in Lampasas County, Texas.
http://www.geo.utexas.edu/scientist/milliken/barnettshale.htm



Paleogeography of the Eastern United States During the Early Late Ordovician

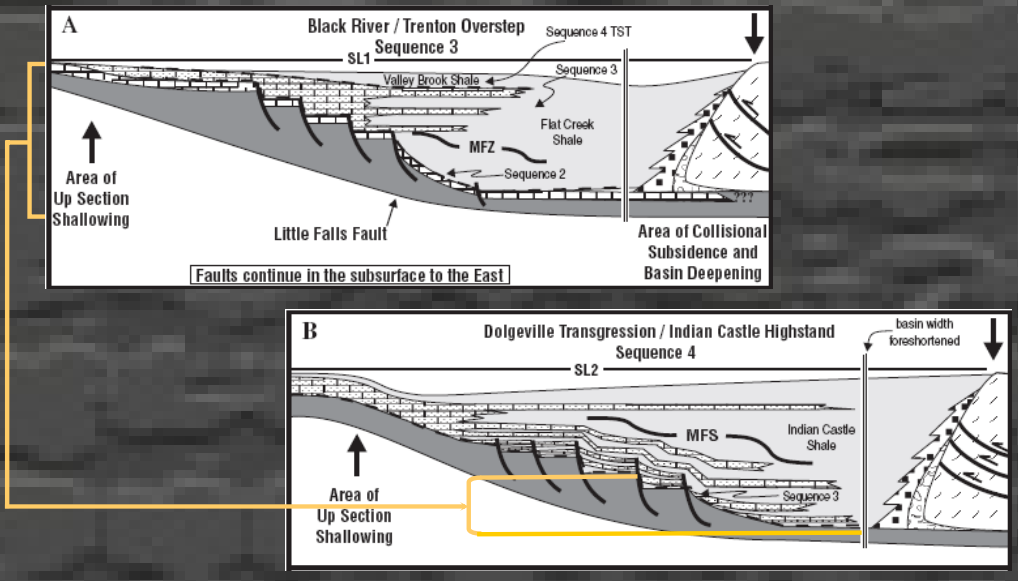


Modified from Bradley and Kidd, 1991.
http://zircon.geology.union.edu/gildner/tectonicXsec.html



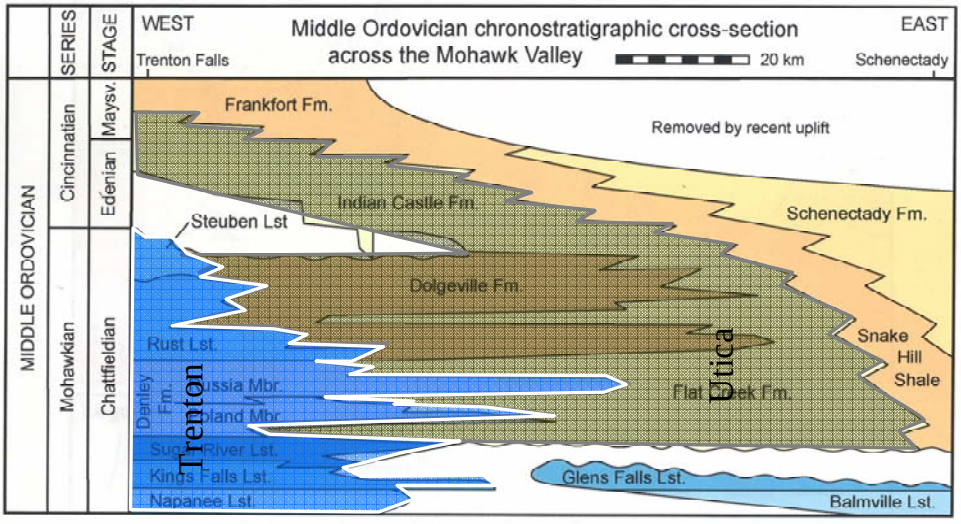
Modified after Cornell (2003),
www.mcz.harvard.edu/Departments/InvertPaleo/Trenton/Intro/GeologyPage/Geologic%

Trenton Shelf and Taconic Foredeep Basin



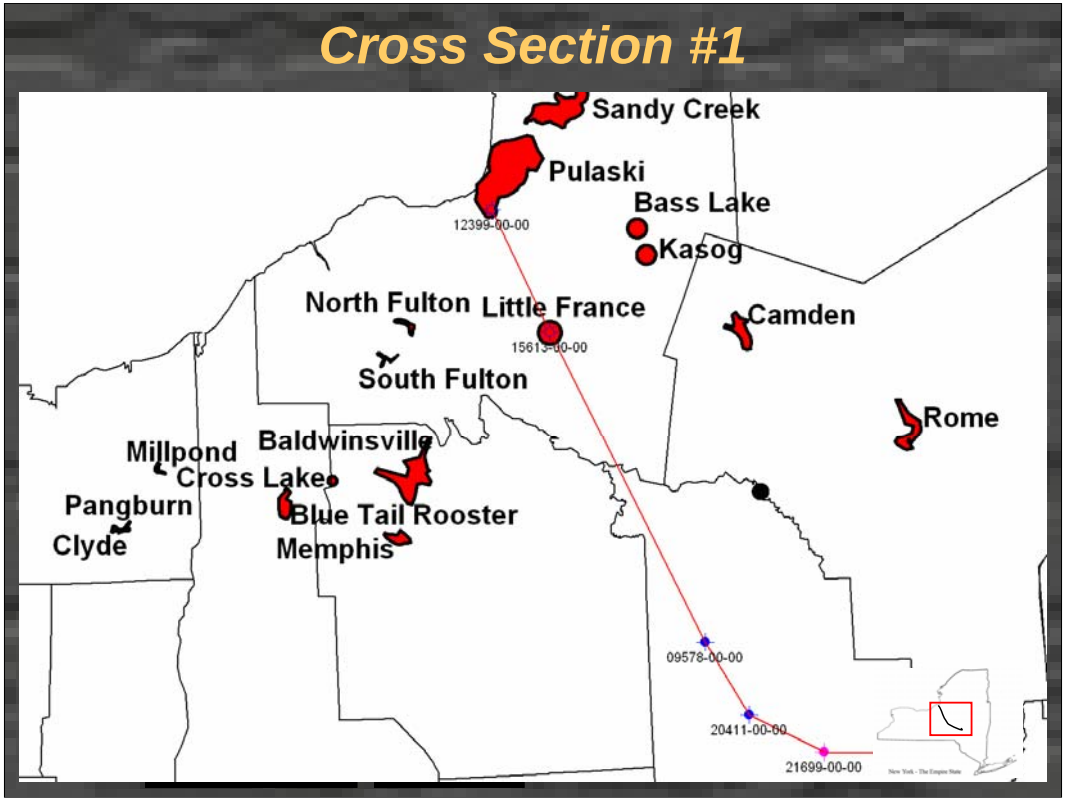
Joy, Michael P., Charles E. Mitchell and Soumava Adhya, Evidence of a tectonically driven sequence succession in the Middle Ordovician Taconic foredeep, Geology, August 2000, p. 727–730.

Utica Shale Stratigraphy

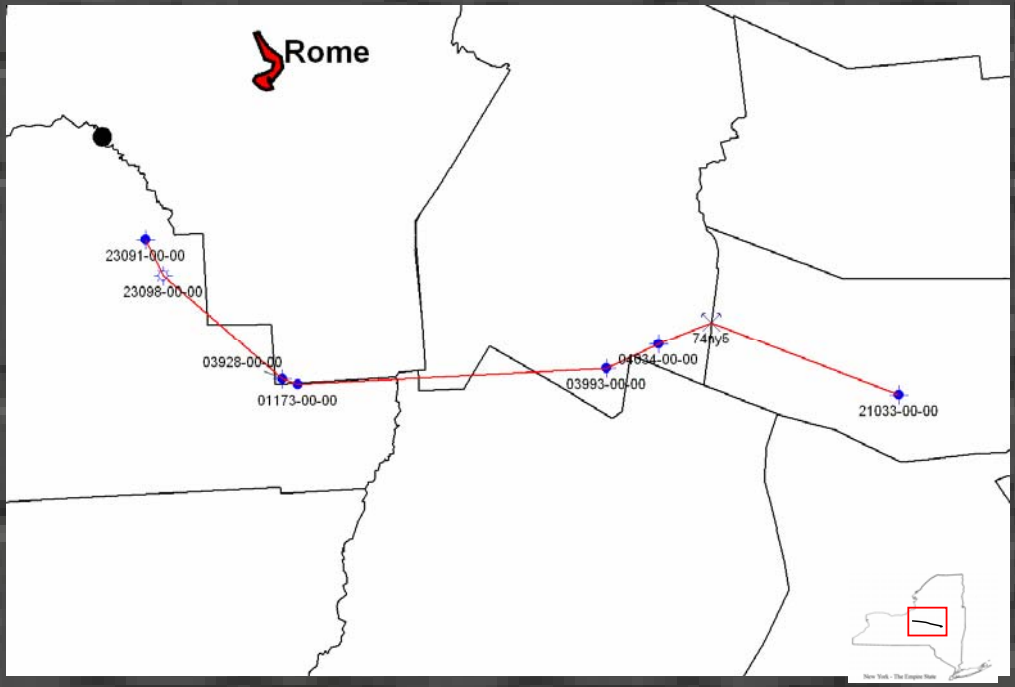


Cross, Gareth E., *Fault-Related Mineralization in the Mohawk Valley, Eastern New York State*, Master's Thesis, SUNY at Buffalo. 2004.

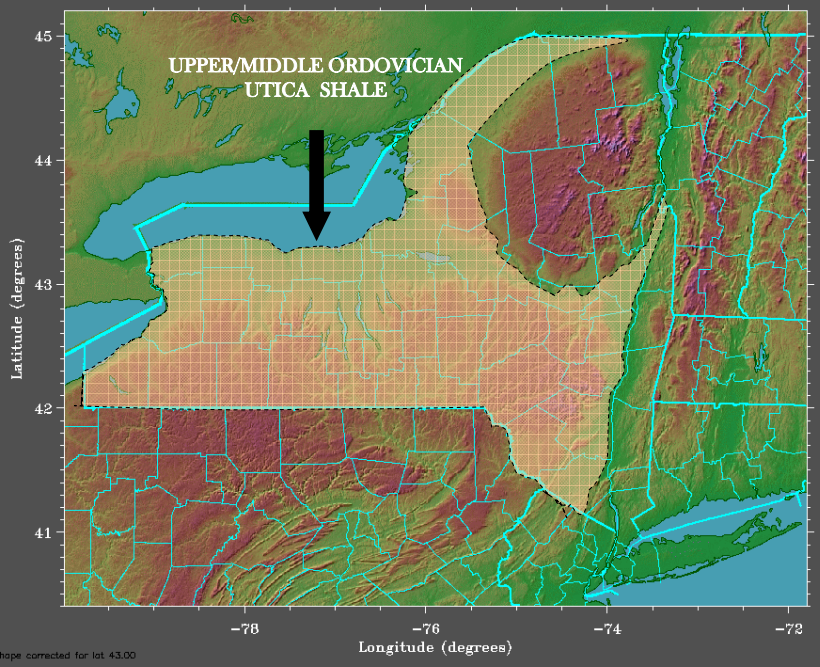
Cross Section #1



Cross Section #2

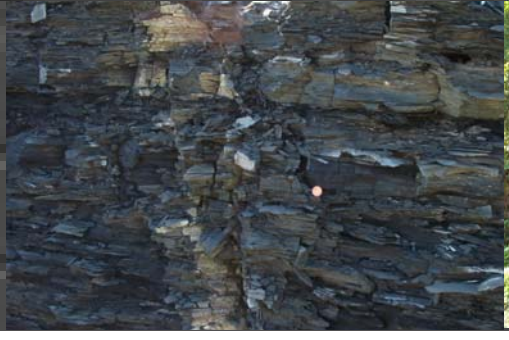


Extent of Ordovician Utica Shale

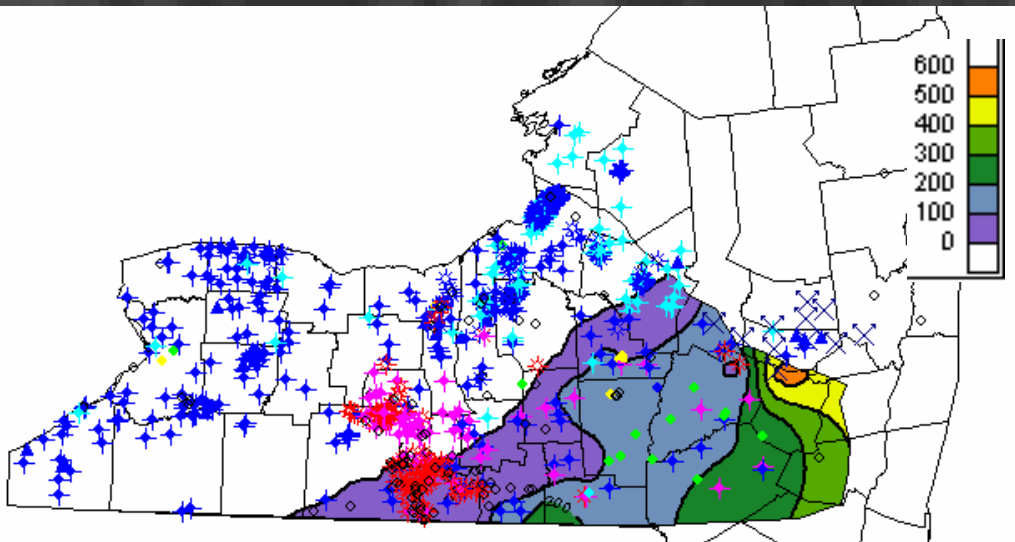


Flat Creek Member

- Transgressive deep basinal calcareous black shale (first mud flux)
- Pictures are from the towns of Fonda (left) and Florida, Montgomery Co.



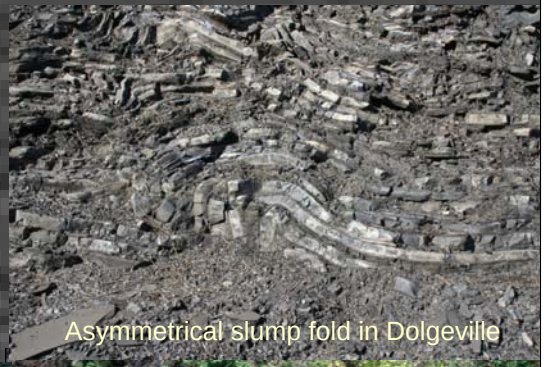
Flat Creek Isopach Map



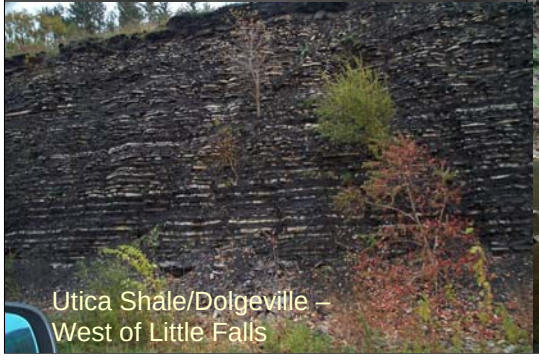
Flat Creek member thickens to the southeast (all Utica data points shown)

Dolgeville Member

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



Asymmetrical slump fold in Dolgeville

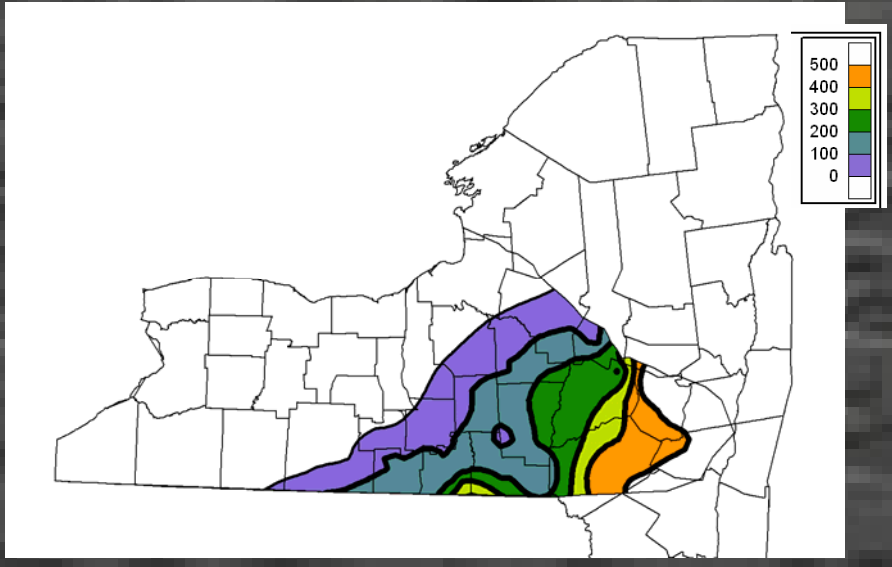


Utica Shale/Dolgeville –
West of Little Falls

Indian Castle Fm.
(Utica Group)

Dolgeville Fm.
(Trenton Group)

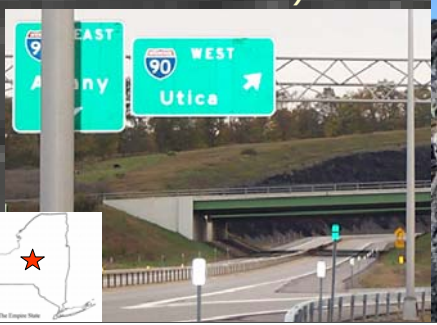
Dolgeville Isopach Map

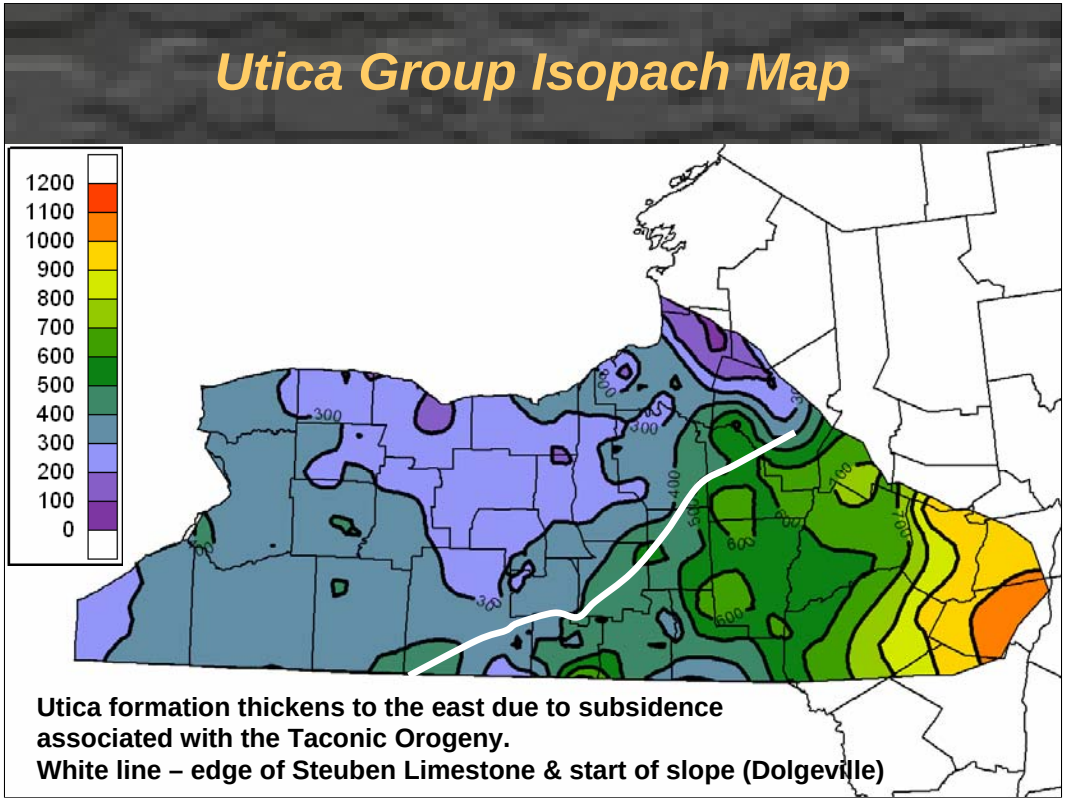


Dolgeville thickens to southeast

Indian Castle Member

- Transgressive, fissile shale with some calcareous interbeds
- Upper (monotonous, fissile) and lower units (blocky with impure limestone beds)



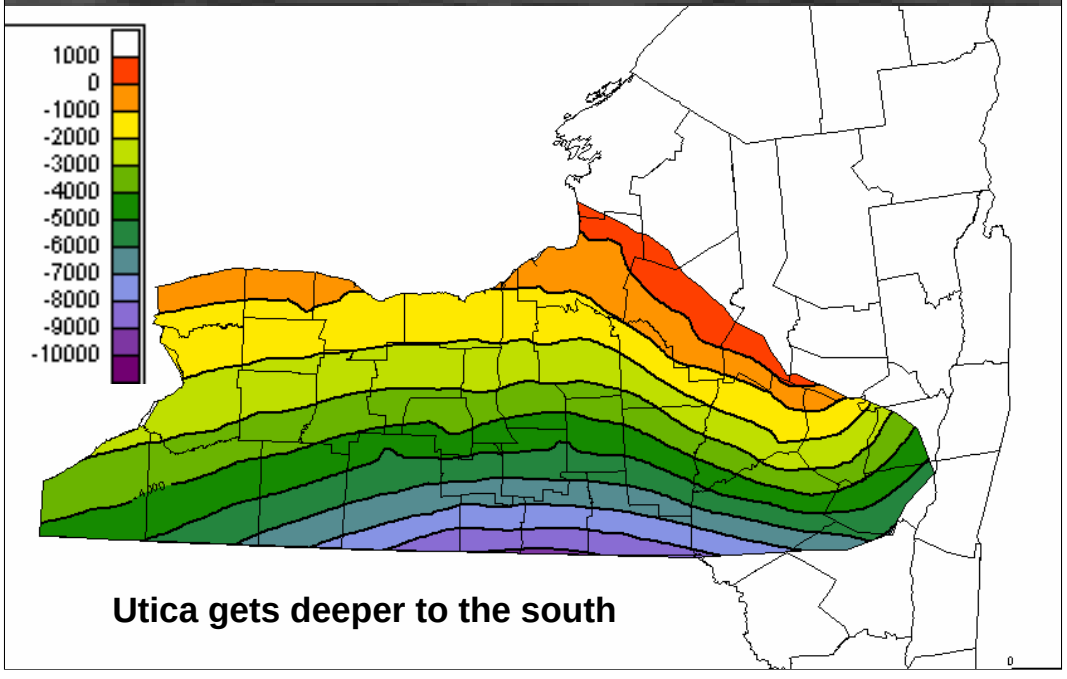


Presenter's Notes:

The Utica thickens to the east where the Flat Creek and Dolgeville are part or the formation.

They cut out when the stuben limeston 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

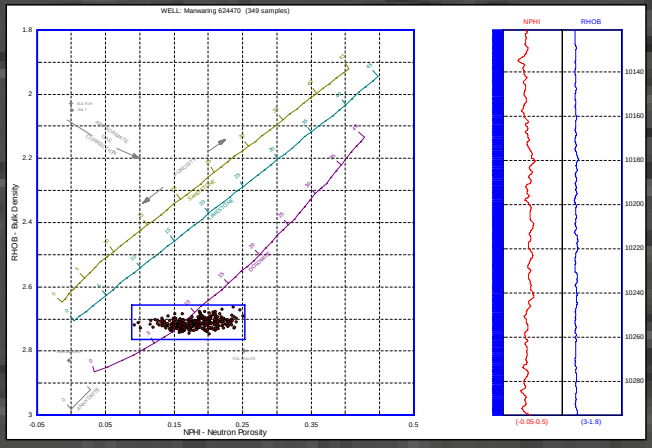
- Mineralogy
- Organic Content
- Thermal Maturity
- RockEval and Adsorption
- Fractures and Rock Fabric

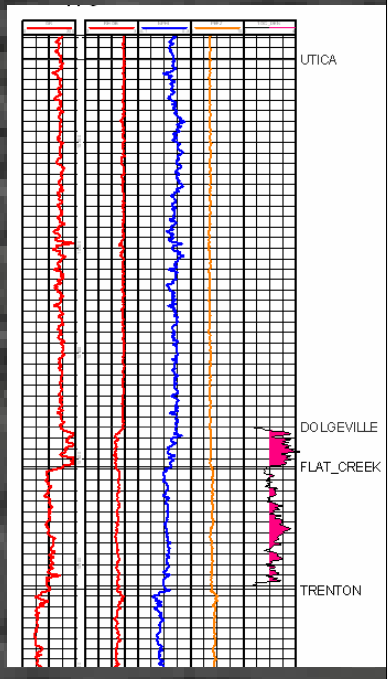
Sample Mineralogy: Volume % XRD

Sample Mineralogy (Volume Percent)	Indian Castle	Flat Creek	Indian Castle	Indian Castle
Quartz	28.00%	9.80%	28.00%	21.00%
K-Feldspar	0.00%	0.70%	0.00%	0.50%
Plagioclase	14.00%	1.60%	9.40%	12.00%
Calcite	12.00%	59.00%	29.00%	28.00%
Dolomite	5.40%	8.10%	6.60%	9.30%
Pyrite	1.40%	0.10%	1.10%	1.20%
Gypsum	0.10%	0.00%	0.50%	0.40%
Illite & Mica	30.00%	20.00%	25.00%	26.00%
Kaolinite	0.10%	0.00%	0.00%	0.00%
Chlorite	8.40%	0.00%	0.60%	0.90%
Total	100%	100%	100%	100%
Calculated Clay Volume	39%	20%	26%	27%
Calculated Grain Density	2.73	2.71	2.71	2.72

XRD Data from EOG Resources

Cross Plot: Upper Indian Castle



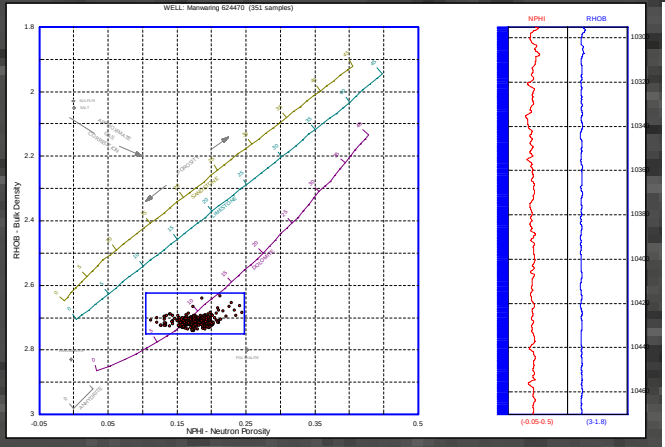


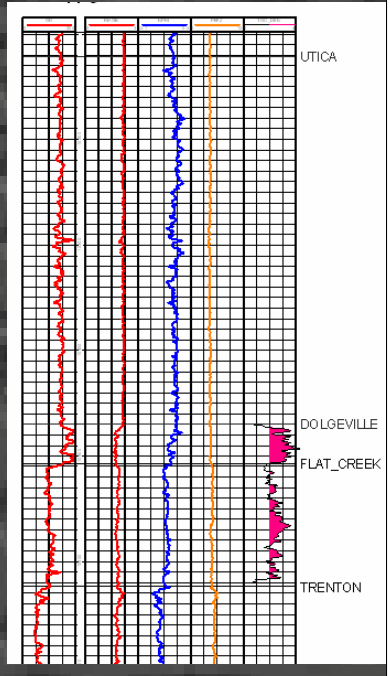
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

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

Upper Indian Castle: Siliceous Shale w/ dolomite

Cross Plot: Lower Indian Castle



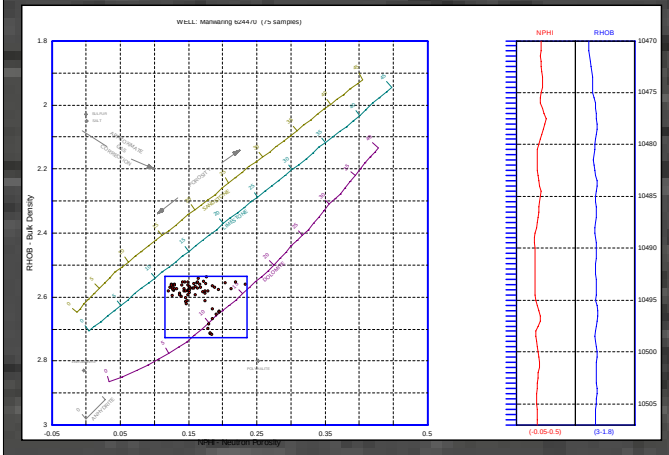


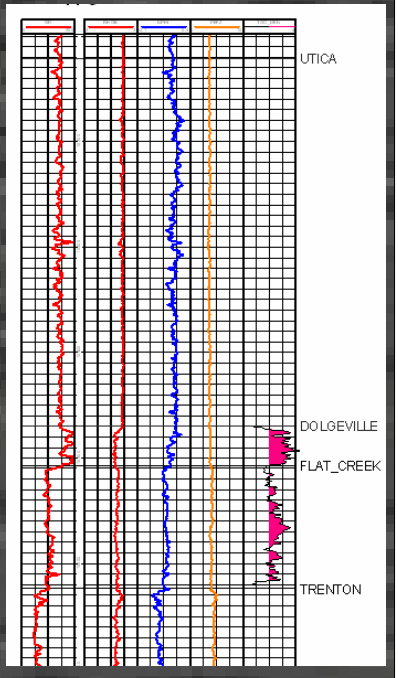
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

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

Lower Indian Castle: Calcareous Shale with varied thickness on limestone beds

Cross Plot: Dolgeville



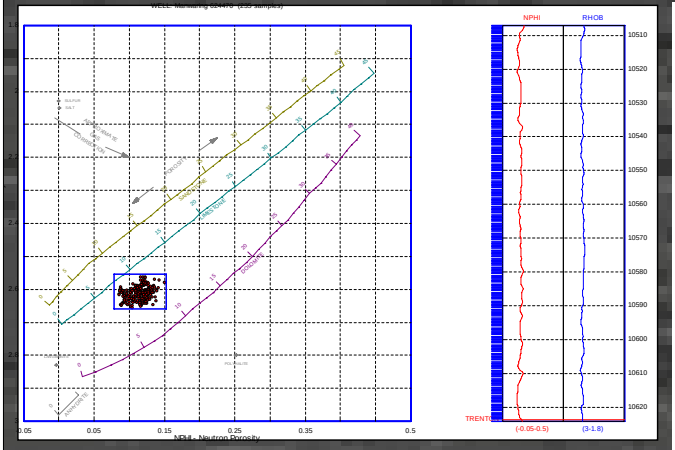


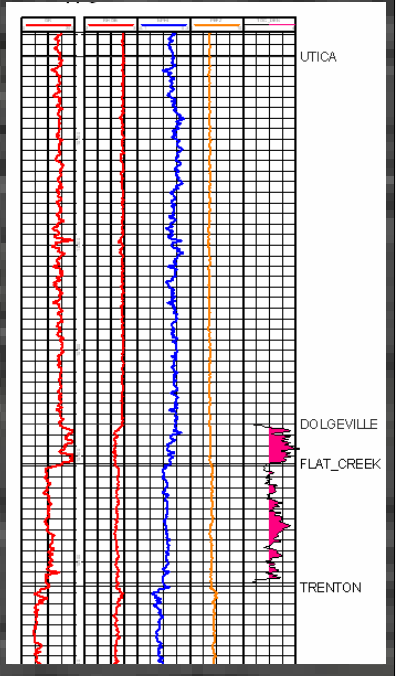
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

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

Dolgeville: rhythmic shale and limestone

Cross Plot: Flat Creek



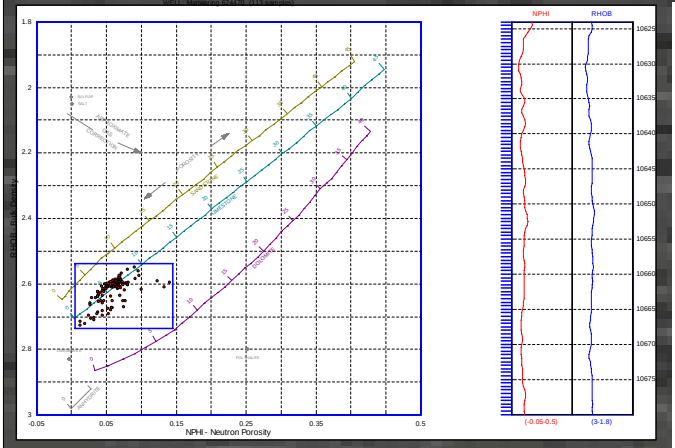


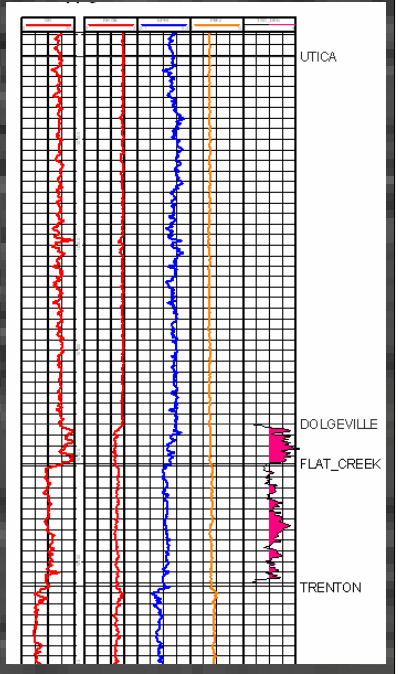
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

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

Flat Creek: black calcareous shale

Cross Plot: Trenton Rust Member



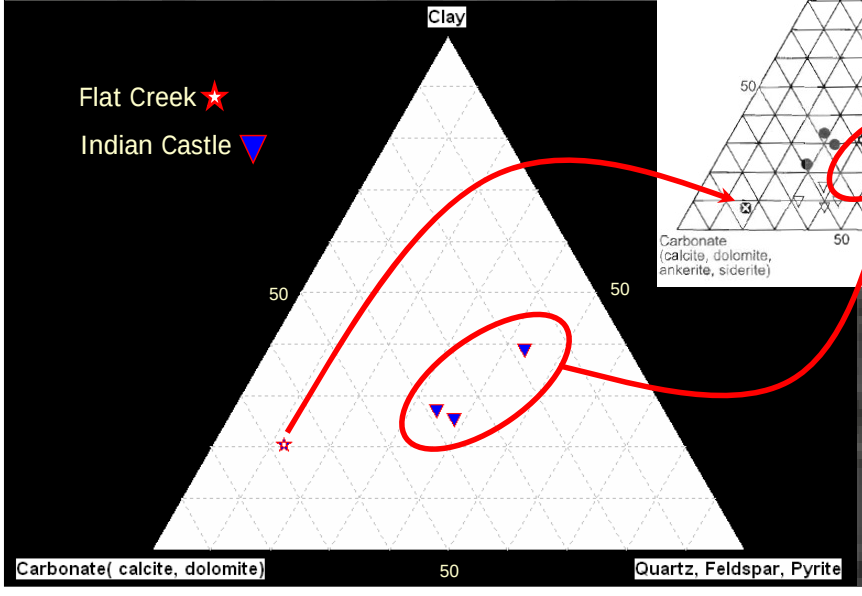


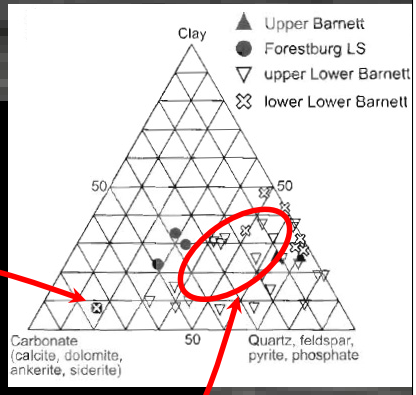
Plot of RHOB (bulk density) vs. Neutron Porosity showing mineralogical relationships.

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

Trenton Rust Member: silty limestone

Ternary Diagrams: Utica & Barnett





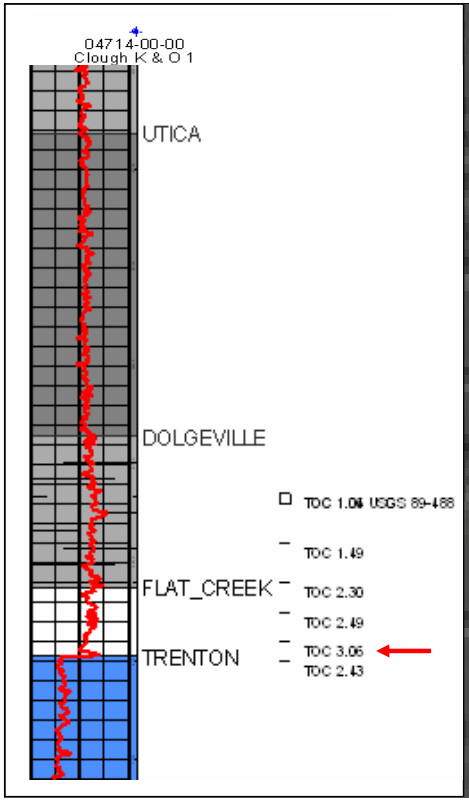
Loucks and Ruppel, 2007

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%)

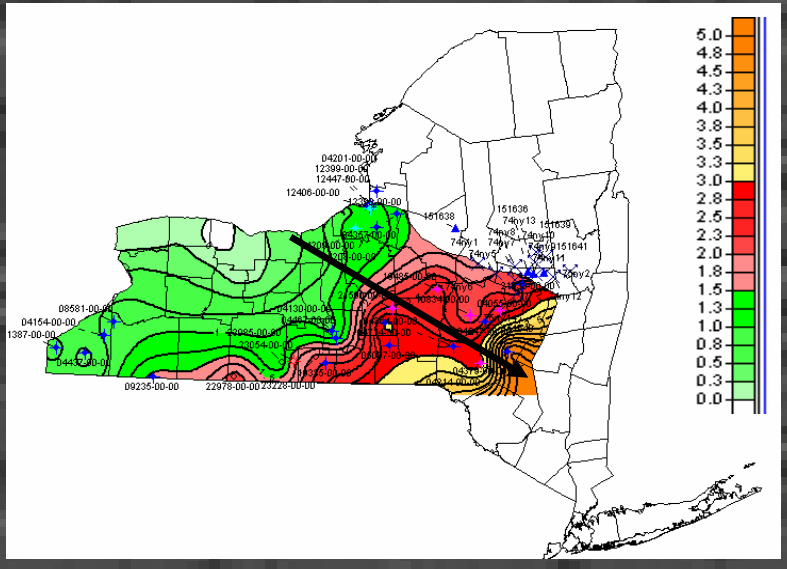
In Jarvie et al., 2005 study TOC from cuttings were 2.36 times lower than samples from core, therefore this same dilution effect would be seen on other geochemical parameters



Gamma Ray Log & TOC measurements

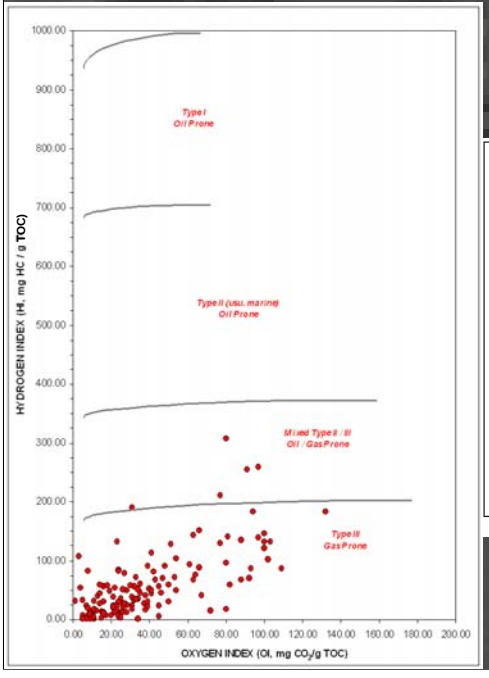
- TOC measurements made on well cuttings, cores and outcrop
- Subtle shift in gamma ray curve is due to increased organic content
- TOC is increasing in basal part of Utica (Flat Creek)
- Repeatable gamma ray curve has changed character due to increased TOC

Utica TOC Map



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).

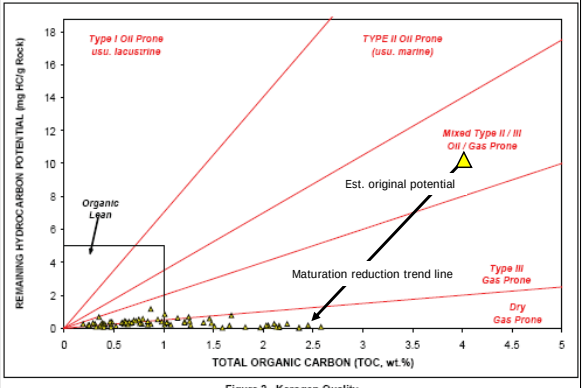


Figure 2. Kerogen Quality

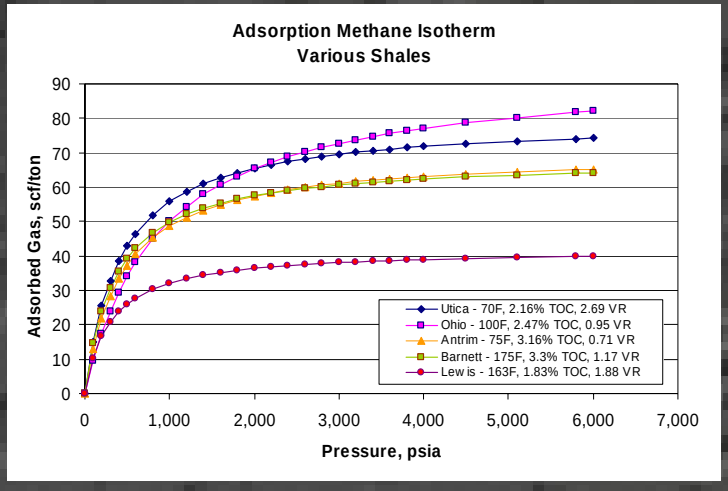
Data source: NYS Museum and Wallace and Roen, 1989

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



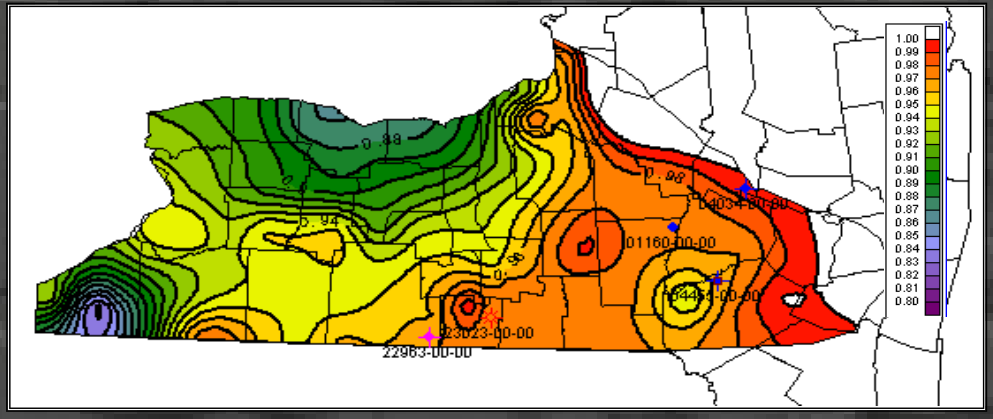
Laboratory methane isotherms for various shales in the U.S. for comparative purposes

- Note different experiment temperatures, and
- Different shale maturations as expressed by vitrinite reflectance

Presenter's Notes:

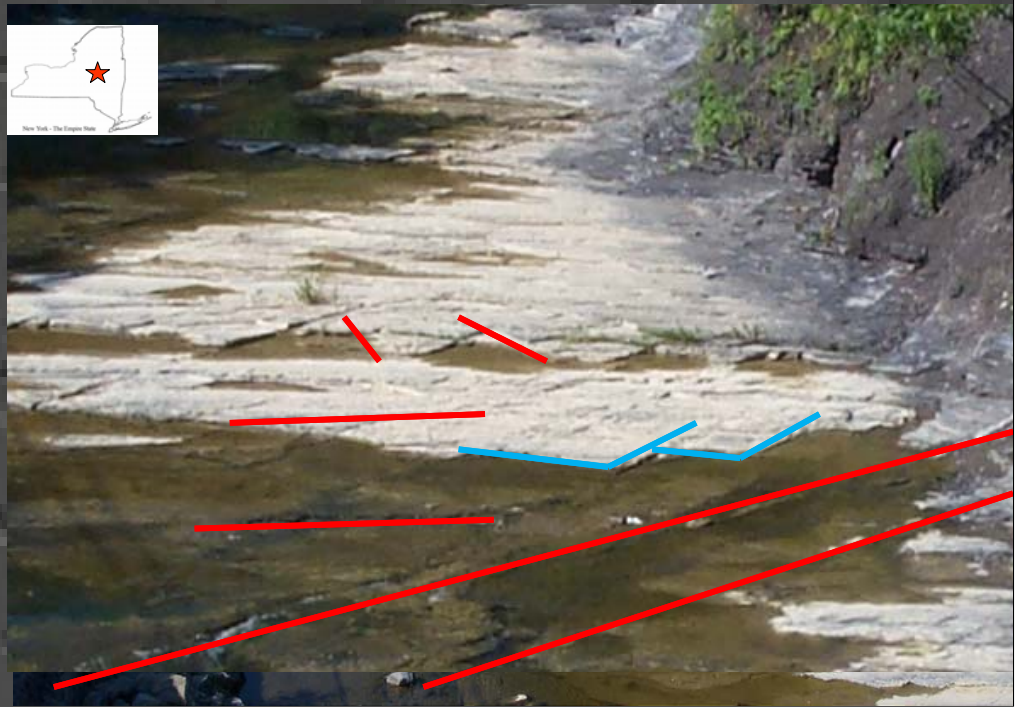
This slide shows laboratory methane isotherms from various gas shale in the US. While the TOC values are in a similar range, the experimental temperature and vitrinite reflectance values are notably different. Gas storage by adsorption is inversely proportional to temperature. So for lower temperature 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.

Transformation Ratio



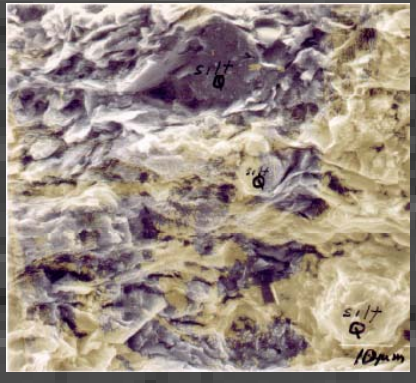
In order to calculate this ratio, you need the present day Hydrogen index (HIpd) and original Hydrogen index (HIo) (see Jarvie et al., 2007 for formula)

Fracture Sets in Flat Creek Member



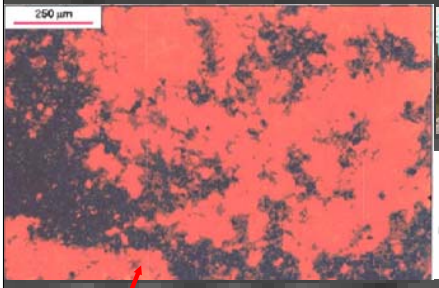
Indian Castle Rock Fabric: SEM Image

Watertown, NY Area



Outcrop sample from near bottom of Utica shows clay and silt-size quartz. Image taken by Neal O'Brien, SUNY Potsdam, 9/17/85.

Flat Creek (?) Rock Fabric: SEM Images



"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."

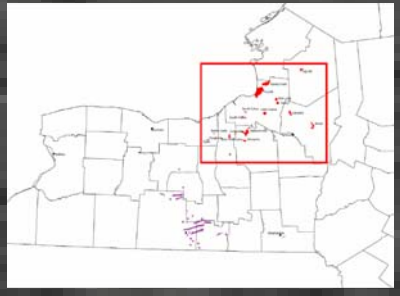
Rocky Mountain Geological Limited, Petrographic Evaluation of Pore & Fracture Systems (prepared for EOG Resources and used with permission), August 2002

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

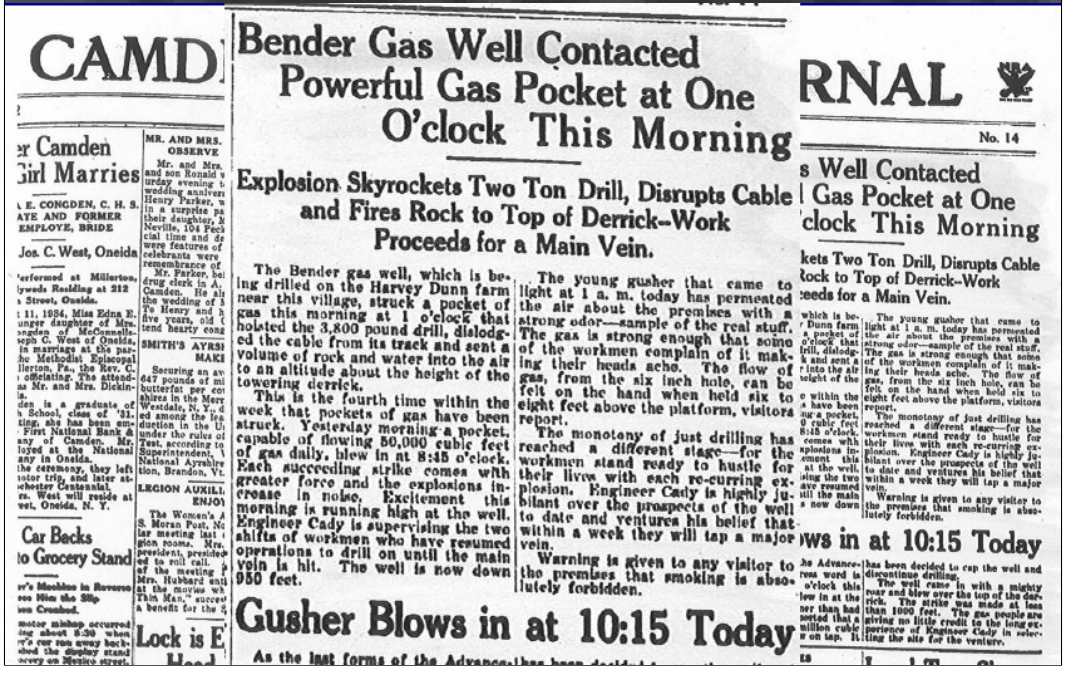
- The typical well has several very high pressure gas shows
- The gas will flow at a high rate for a few hours or days and then drop off to a very low rate of ~10 mcfd.
- It will flow at this rate for decades.
- Drilling practice was to drain high-rate producing intervals and then drill deeper.
- A few wells have sustained higher rates for longer periods of time (probably vertical fracturing near faults).



Early Geological Characterization

"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***

Hype! These Wells Were Big News



CAMD

er Camden Girl Marries

E. CONGDEN, C. H. S. ATE AND FORMER EMPLOYE, BRIDE

Jos. C. West, Oneida

erformed at Millerton, lywoods Reading at 212 Street, Oneida.

11, 1934, Miss Edna E. unger daughter of Mrs. ngden of McConnells. seph C. West of Oneida, in marriage at the par- he Methodist Episcopal llerton, Pa., the Rev. C. officiating. The attend- as Mr. and Mrs. Dickin- la.

den is a graduate of h School, class of '31. ting, she has been em- First National Bank & any of Camden. Mr. loyed at the National any in Oneida.

the ceremony, they left otor trip, and later at- chester Centennial. rs. West will reside at est, Oneida, N. Y.

Car Becks to Grocery Stand

r's Machine in Reverse ses Him the Slip ses Crushed.

motor mishap occurred ing about 8:30 when r's car ran away back- shed the display stand ercery on Mexico street.

MR. AND MRS. OBSERVE

Mr. and Mrs. and son Ronald v urday evening t wedding anniver Henry Parker, n in a surprise pa their daughter, M Neville, 104 Fech cial time and de were features of celebrants were remembrance of

Mr. Parker, hei drug clerk in A. Camden. He al the wedding of M To Henry and h five years, old (tend hearty cong

SMITH'S AYRSI MAKE

Securing an av 647 pounds of mi butterfat per cov shires in the Mer Westdale, N. Y. d ed among the lea duction in the U under the rules of Test, according to Superintendent, V National Ayrshire tion, Brandon, Vt.

LEGION AUXILI ENJO

The Women's A S. Moran Post, No lar meeting last gion rooms. Mrs. president, presided ed to roll call. of the meeting p Mrs. Hubbard ent at the movies wh This Man," succes a benefit for the G

Lock is E Flood

Bender Gas Well Contacted Powerful Gas Pocket at One O'clock This Morning

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

The Bender gas well, which is being drilled on the Harvey Dunn farm near this village, struck a pocket of gas this morning at 1 o'clock that hoisted the 3,800 pound drill, dislodged the cable from its track and sent a volume of rock and water into the air to an altitude about the height of the towering derrick.

This is the fourth time within the week that pockets of gas have been struck. Yesterday morning a pocket, capable of flowing 50,000 cubic feet of gas daily, blew in at 8:45 o'clock. Each succeeding strike comes with greater force and the explosions increase in noise. Excitement this morning is running high at the well. Engineer Cady is supervising the two shifts of workmen who have resumed oprrations to drill on until the main vein is hit. The well is now down 950 feet.

The young gusher that came to light at 1 a. m. today has permeated the air about the premises with a strong odor—sample of the real stuff. The gas is strong enough that some of the workmen complain of it making their heads ache. The flow of gas, from the six inch hole, can be felt on the hand when held six to eight feet above the platform, visitors report.

The monotony of just drilling has reached a different stage—for the workmen stand ready to hustle for their lives with each re-curring explosion. Engineer Cady is highly jubilant over the prospects of the well to date and ventures his belief that within a week they will tap a major vein.

Warning is given to any visitor to the premises that smoking is absolutely forbidden.

Gusher Blows in at 10:15 Today

As the last forms of the Advance-

RNAL

No. 14

s Well Contacted Gas Pocket at One clock This Morning

kets Two Ton Drill, Disrupts Cable lock to Top of Derrick--Work ceeds for a Main Vein.

which is be- Dunn farm a pocket of o'clock that frill, dislodg- k and sent a r into the air eight of the

o within the a have been ne a pocket, 0 cubic feet 8:45 o'clock. comes with xplosions in- cement this at the well, sing the two ave resumed till the main a now down

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ws in at 10:15 Today

he Advance- ress word is o'clock this low in at the ner than had ported that a illion cubic r on tap. It

has been decided to cap the well and discontinue drilling.

The well came in with a mighty roar and blew over the top of the derrick. The strike was made at less than 1000 feet. The gas people are giving no little credit to the long experience of Engineer Cady in selecting the site for the venture.

And the Utica in Quebec: Modern Hype!

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.

UTICA SHALE PLAY IN QUÉBEC –

FOREST OIL ANNOUNCED NEW TREND
Company could be exposed to 4 Tcfe of net recoverable shale gas

SHALE GAS PROJECT : THE FIRST FRAC IN QUEBEC'S HISTORY

January 22, 2008 – Québec (Québec) // Junex Inc. (JNX : TSXV) ... This is the first time in Quebec's history that this type of work is performed with the purpose of evaluating the Shale gas potential.

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

	Barnett	Utica-Quebec	Utica- New York	Marcellus-New York
Depth (ft)	4,500-9,000	2,300-6,000	0-12,000+	0-6,000+
Thickness (ft)	150-700	500	300-1,200+	10-1,300
Clay Content (%)	15-30	15-26	20-27	11-49
TOC (%)	3.5-5.0	1.0-3.1	1.0-5	4.5-12
Porosity (%)	3.0-4.8	3.2-3.7	4.34-6.45	Est. 0.5-2.5
Pressure (psi/ft)	.46-.50	.45-.60	Est. .20-.40	Est. 0.25-.4
Maturity (R0)	1.0-2.2	1.3-2.0	1.8-2.5	0.5-3.0

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 Inc., Montreal, took a farmout from Utica Energy LLC, private New York operator, to drill one horizontal and five vertical wells in New York state by Jan. 16, 2009.

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.

Oil and Gas Journal, Volume 106 Issue 12 Mar 24, 2008

And Some Hype is Self-Induced…

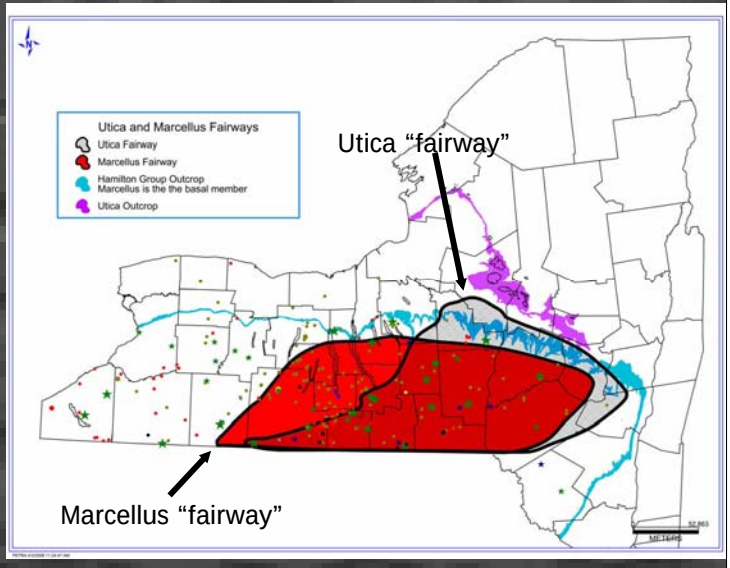
From Gas Daily 4/7/08

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.

Monument at Fredonia, New York
"The Site of the First Gas Well in the United States. Lighted in Honor of General Lafayette's Visit, June 4, 1825"