Geological Framework for Natural Gas Development in Central New York
Natural gas is a fossil fuel that is derived from ancient, buried organic matter. Natural gas is a mixture of methane, ethane, propane and butane, and is found in many sedimentary rocks. For the gas to be extracted in commercially viable amounts a natural reservoir system is required.

This presentation focuses on the natural gas developments in Central New York, with special emphasis on new reservoir systems that are being tapped. The application of horizontal drilling, and potentially, hydrofracturing technologies, in shale gas reservoirs has opened potential development in areas that have previously seen little or no activity. This presentation includes some information regarding environmental concerns related to oil and gas development. A more detailed analysis of these issues can be found at

http://offices.colgate.edu/bselleck/NatGas/Envhealthnatgas.pdf
A Chenango resource finally gets tapped

For years, Chenango County has been looking for a way to develop its natural gas resources. Recently, Norse Energy Inc. announced plans to drill a well in the area, which would be the first in the region. The well is expected to produce gas for the next 10 years and is expected to create jobs and stimulate the local economy.

The well will be a horizontal gas well, which means it will extend horizontally into the shale formation. This allows for more efficient extraction of natural gas and can be more environmentally friendly than vertical wells.

Norse Energy will be using advanced drilling technology to extract the gas from the shale formation. The company has already invested in the necessary equipment and has received all the necessary permits from the state and federal governments.

The well is expected to be completed by the end of the year, and Norse Energy plans to begin production in early 2024. The company expects the well to produce up to 20 million cubic feet of gas per day.

This is a significant development for Chenango County, which has been looking for ways to diversify its economy and create new jobs. The well is expected to generate $2 million in tax revenue for the county each year.

Overall, this is a promising development for Chenango County and the region as a whole. With the growth of the natural gas industry, we can expect to see more jobs and economic opportunities in the future.

---

Testing Recommendations for Residential Wells Neighboring Gas Well Development Sites

Water testing is necessary to determine the quality of new drinking water wells, and it is especially important to periodically evaluate existing well water quality. With the increase in gas well development sites in Madison County, concerned residents in proximity to such activities may also wish to conduct testing to determine if contaminants are present in their drinking water well.

The water quality parameters listed below may be useful if measured prior to and after the commencement of such gas drilling activity to assess possible impacts. It is typically recommended to conduct sampling for basic water quality parameters and for contaminants commonly found in groundwater prior to the start of drilling to establish baseline indicators, and such analyses repeated along with testing for more specific contaminants are more likely to occur from such gas drilling activities after the drilling has been completed.

<table>
<thead>
<tr>
<th>Basic Parameters</th>
<th>Common Contaminates Found in Groundwater</th>
<th>Potential Gas Well Pollutants</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Total Dissolved Solids (TDS)</td>
<td>Methane, Methane</td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids (TSS)</td>
<td>Volatile Organic Compounds (VOC)</td>
</tr>
<tr>
<td>Hardness</td>
<td>Iron</td>
<td>Dissolved Metals (DissMet)</td>
</tr>
<tr>
<td>Sulfide</td>
<td>Hydrogen Sulfide</td>
<td>Strontium</td>
</tr>
<tr>
<td></td>
<td>Ammonia</td>
<td>Calcium</td>
</tr>
</tbody>
</table>

This Health Department recommends testing for total coliform, which can indicate bacteriological contamination, in addition to testing for nitrate (total approx. cost $40), be conducted annually for anyone served by an individual water well. New residential water wells should be tested for these recommended water quality parameters listed on Individual Water Supply Wells – Fact Sheet #3 prepared by the NYS Health Department (NYSDOH) and which is available from the following website:

http://www.health.state.ny.us/environmental/water/drinking/pant/appendix/603_water_quality.html

All potable water samples should only be analyzed by a laboratory properly certified by the NYSDOH Environmental Laboratory Approval Program (ELAP). A current list of ELAP certified laboratories is available at http://www.wadsworth.org/lablist/asp.html or by contacting the local Health Department. Note that each laboratory may approach baseline testing differently depending on area served and familiarity, and costs may vary accordingly.
Adirondack Mountains

Lake Ontario

Lake Erie

New England Appalachian Mountains
This map depicts the distribution of gas and oil fields in New York State in 1980. Virtually all of the historical development has been in the western part of the state. No oil has been recovered from wells east of the Finger Lakes region, but there is considerable potential for natural gas.

All of the oil and gas in New York is found in Paleozoic sedimentary rocks which were deposited from 520 to 300 million years ago. Most of these rocks were laid down in a sedimentary basin – the Appalachian Basin – that stretched across eastern north America from Nova Scotia to Alabama.
What is ‘natural gas”?

‘Hydrocarbons’ are C-H compounds with C-H and C-C bonds.

Breaking of these bonds by oxidation (combustion) releases heat energy

Most common petroleum and gas hydrocarbons are alkanes, with the general formula - \( C_nH_{2n+2} \)

Natural gas has the lowest carbon footprint of any fossil fuel – and is made up mostly of methane -

\[ \text{CH}_4, \text{with some ethane} - \text{C}_2\text{H}_6, \text{propane} - \text{C}_3\text{H}_8 \text{and butane} - \text{C}_4\text{H}_{10} \]

‘Heavier’ alkanes - pentane, hexane, heptane, octane, etc - are liquid at surface temperatures and pressures

Liquid petroleum is a mixture of \( \text{C}_5 \) to \( \text{C}_{30} \) alkanes, plus aromatics (e.g. benzene) and alkenes

Methane is also produced by a variety of biological processes at the earth’s surface

methane from surface biological systems is rarely accompanied by ethane, propane or butane

methane from biological systems can be distinguished from natural gas (petroleum system) methane using carbon and hydrogen stable isotope ‘fingerprinting’

Petroleum system natural gas is usually associated with minor liquid hydrocarbons (wet gas with condensate)

Dry gas systems are most common in sedimentary rocks that have been heated above 140ºC

Brine (formation water) is produced from most natural gas wells and must be safely disposed of
Where does it come from?
The most common unit of measure for natural gas is the MCF

1 MCF = 1000 cubic feet of gas at surface temperature and pressure. This is approximately equal to 1,000,000 BTU

1 Therm = 100,000 BTU --- 1 MCF is approximately 1000 Therm

A typical residence in the NE US would consume ~73 MCF for domestic heating in one year

In 2008:

NYS consumed 1,190,341,000 MCF of natural gas
NYS produced 50,320,077 MCF of natural gas = 4.2% of consumption

7790 natural gas wells in NY had production reported

the top 100 producing wells accounted for 70% of the states production

76 of the top 100 wells produced gas from the Trenton-Black River reservoir system

other producing formations in the top 100 – Theresa (5 wells); Oneida (5); Herkimer (4)

Chenango County in 2008:

427,609 MCF (=~ $3,000,000 at January 2008 wellhead price of $6.99/MCF)

18 wells – top producer at ~95,000 MCF is a Herkimer well
Subsurface exploration prior to drilling depends on seismic data. Modern seismic exploration technology allows developers to precisely target the highest-quality portions of reservoir formations. Grids of seismic data are used to construct 3-D subsurface seismic sections.

The map on the left shows routes for Vibroseis exploration in the towns of Lebanon, Smyrna and Plymouth.

2-D Seismic section (not from the Lebanon area)
Well logs are prepared during and immediately after drilling. The ‘log’ may consist of a number of remotely sensed parameters (density, gamma ray, neutron) and a lithologic log prepared from well cuttings or, more rarely, from cores. Well logs are used to characterize reservoirs, determine the geometry of ‘pay zones’ and direct further exploration and development. Well log data and well cuttings are available from the New York State Museum.
Drilling of a gas well requires construction of a drilling pad and access roads, and moving in and out of heavy equipment. Development of the well may involve installation of casing and cement sheath, and treatment of the producing formation to increase gas flow into the well. The above-ground equipment is not visually obtrusive; pipelines, valves and compressor facilities pose some safety risk. Properly designed and maintained wells do not offer significant environmental hazard.
Rock strata in central New York dip gently to the southwest. This cross-section exaggerates the dip and shows the sedimentary units and their ages. The oldest rocks in New York are the 1.1 billion year old metamorphic and igneous rocks of the Adirondacks. These ancient rocks contain no oil or gas, but host deposits of metals ores for iron, titanium, lead and zinc, and useful minerals like talc, wollastonite and garnet.

The red pattern indicates rock units that may serve as reservoir beds in central and western New York.
Utica Shale Gas Potential

Subsurface Utica Shale at reasonable reservoir depths

Utica Shale high probability fairway
Herkimer Sandstone outcrop near Jordanville, NY
Most gas wells in Chenango County tap reservoirs in the Oswego/Oneida/Herkimer sandstones. The Utica Shale that underlies the sandstone may be source bed for the gas. Minor fold structures in the sandstone help to trap the gas in commercial quantities. Wells in the Town of Smyrna are developed in a minor fold structure where the sandstone is unusually thick. The overlying Ilion Shale forms a seal on the reservoir sandstone. Wells are typically 2500-4000' deep.

Deeper wells (greater than 10,000 feet) in the eastern Finger Lakes region have encountered large reservoirs in the Trenton-Black River Group trend. Trenton-Black River discoveries are related to deep fault structures and have proven difficult to locate, but very profitable when exploited.

Schematic model of the Bradley Brook Natural Gas Field
Plan: Bramburger, C. #1H (Bramburger, C. #1H/Bramburger, C. #1H)

Horizontal Well in Herkimer Sandstone
Town of Lebanon, Madison County

Depth in Feet

Marcellus
Onondaga
Oriskany
Helderberg
Camillus
Syracuse
Vernon
Lockport
Willowvale
Marcellus Shale outcrop near Chittenango, NY
Marcellus Shale Gas Potential

Subsurface Marcellus Shale at reasonable reservoir depths.

Marcellus Shale high probability fairway
Natural gas production in Chenango County is almost entirely from the Oswego Sandstone-Herkimer Sandstone-Oneida Conglomerate interval.

While there has been much speculation about the potential for natural gas development from the Marcellus Shale, the most likely areas for development are where the Marcellus is at depths great enough (>1500 feet) to assure reasonable formation pressure and reservoir integrity.

The map on the left shows areas in southern Madison and Chenango County where the Marcellus Shale unit lies at depths great enough (red color contours) for likely development. Areas with green contours have Marcellus Shale at depths less than 1500 feet.

The Utica Shale, another potential shale gas target, underlies all of Madison and Chenango County. The Utica Shale potential may exceed that of the Marcellus in Chenango County.
Cross-section illustrates the schematic subsurface distribution of the Utica Shale, Herkimer Sandstone and Marcellus Shale.
Utica, Herkimer and Marcellus high probability fairways
Fault structures may strongly influence the distribution of some gas reservoirs. Naturally fractured reservoir rocks are sometimes associated with surface lineaments defined by stream valleys or other aligned topographic features. Faults also guide the hydrothermal fluids that lead to Trenton-Black River dolomite reservoirs. However, faults may also cause leakage of gas out of reservoirs.
“Trenton-Black River” reservoirs may exist at greater depths beneath the current levels of Oswego-Herkimer Sandstone exploration in Madison and Chenango Counties. The Glodes Corners Field (discovered in 1991) in Tioga County has been one of the most productive natural gas fields in the Appalachian Basin. These reservoirs occur at depths of 10,000 to 12,000 feet below the surface.
Oil and Gas Fields, MVT Mineral Deposits, and 1400 Ma Transcurrent Basement Faults of the Eastern U.S

Very ancient "basement' fault patterns may influence regional distribution of natural gas reservoirs.
What’s next?

NYSDEC will issue Marcellus and Utica Shale GEIS guidelines in early 2010.

   Expect legal challenges to the guidelines.

   Resolution may not occur until late 2010

Leasing and drilling activity will continue to be slow through most of 2010

Successful horizontal development in Herkimer may attract other players

New federal statues regulating shale gas development are unlikely

US EPA may play a larger role in water quality monitoring in shale gas development areas

Companies will continue to search for elusive new Trenton-Black River fields.

Utica Shale tests, using vertical wells, will continue

Land coalitions will play a larger role in leasing activity, but will be fragile and subject to cherry-picking

Local governments, especially at the township level, must be informed and prepared