Marcellus Shale Natural Gas: The Resource

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New York State Energy Research and Development Authority

The Birth of an Industry: The William Hart Natural Gas Well, Fredonia, NY: 1821

- Drilled the first well specifically designed to find hydrocarbons
- Hart's Firsts:
  - first "dry hole"
  - First gas meter ("gasometer")
  - first natural gas pipeline
  - natural gas distribution company by virtue of selling his gas
- Showed that the "unconventional" was conventional: the producing formation was the Dunkirk Shale

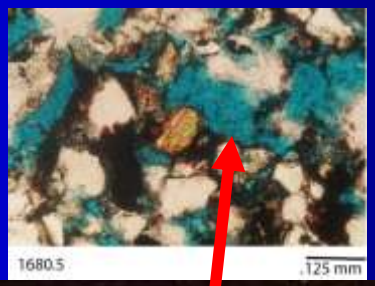
There's a rock and plaque, even, to commemorate!

The What and Why of Shale

- Shale is a fine-grained detrital sedimentary rock, formed by the compaction of clay, silt, or mud.
- 60% of all sedimentary rocks are shale (not all are gas bearing)
- The combustion of natural gas emits almost 30 percent less carbon dioxide than oil, and just under 45 percent less carbon dioxide than coal.

OR

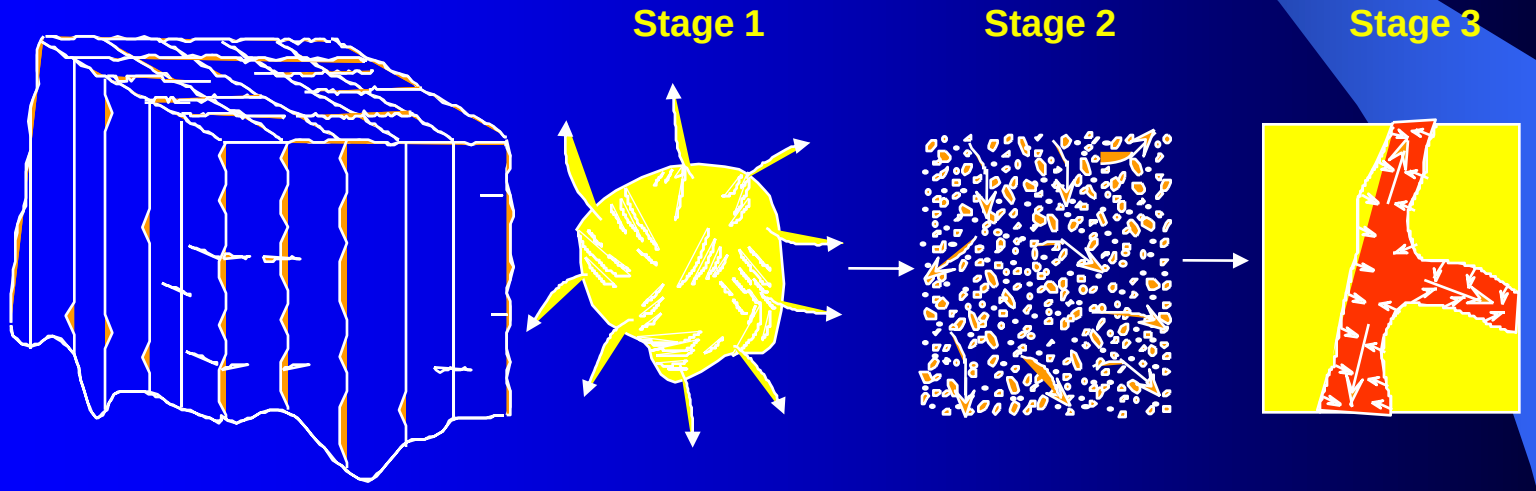
"Messin' with Sasquatch"



Gas Production Mechanism of Shale Source Rock

The "unconventional" nature of shale – source, reservoir and seal

Organic-bearing shales produce from both matrix and organics ("desorption"). Low volumes require thick shale sections and fractures (either natural or induced).



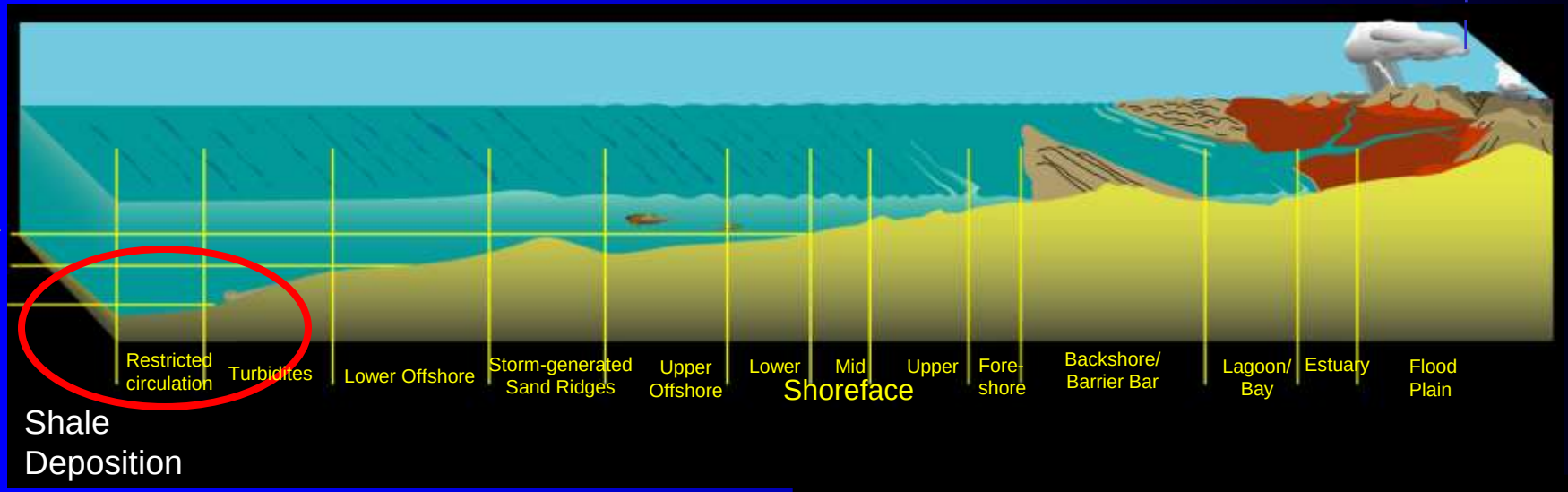
SA1974

SOURCE: Ron McDonald, Schlumberger DCS

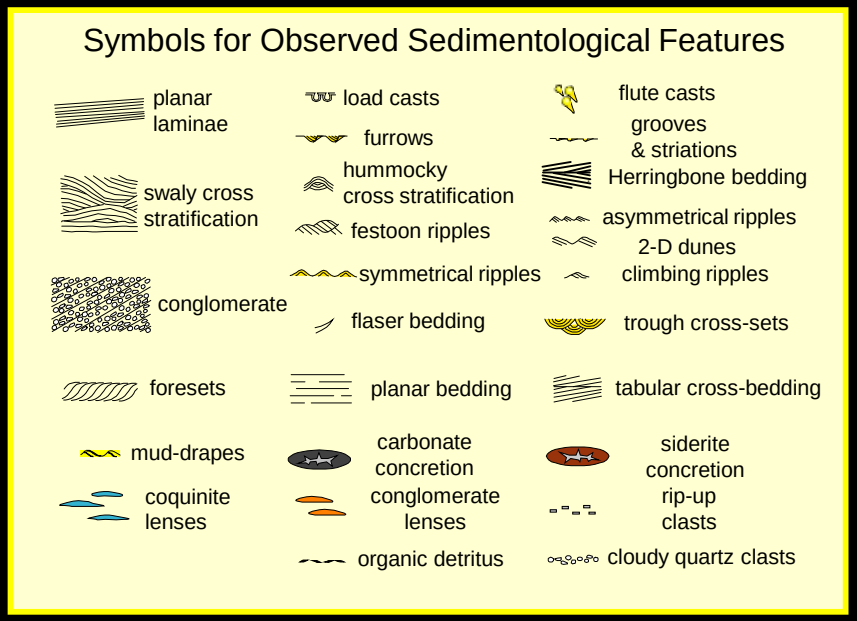
What Makes an Economic "Unconventional" Shale Gas Play?

- **Lots of rock**
  - Large area to drill (many sq. kilometers)
  - Enough formation thickness
- **Good engineering design**
  - Extended-reach wells
  - Hydraulic fracturing
- **Ability to Deliver to Market**
  - *Access to infrastructure*
  - Many shale plays develop in conjunction with conventional reservoirs
  - *Markets and good price*

Depositional Facies of the Upper Devonian Acadian Foreland Basin



The Acadian Foreland Basin did not possess sharp topographic boundaries and form a gentle gradient (e.g. Woodrow and Isley, 1983)



Upper and Middle Devonian Facies

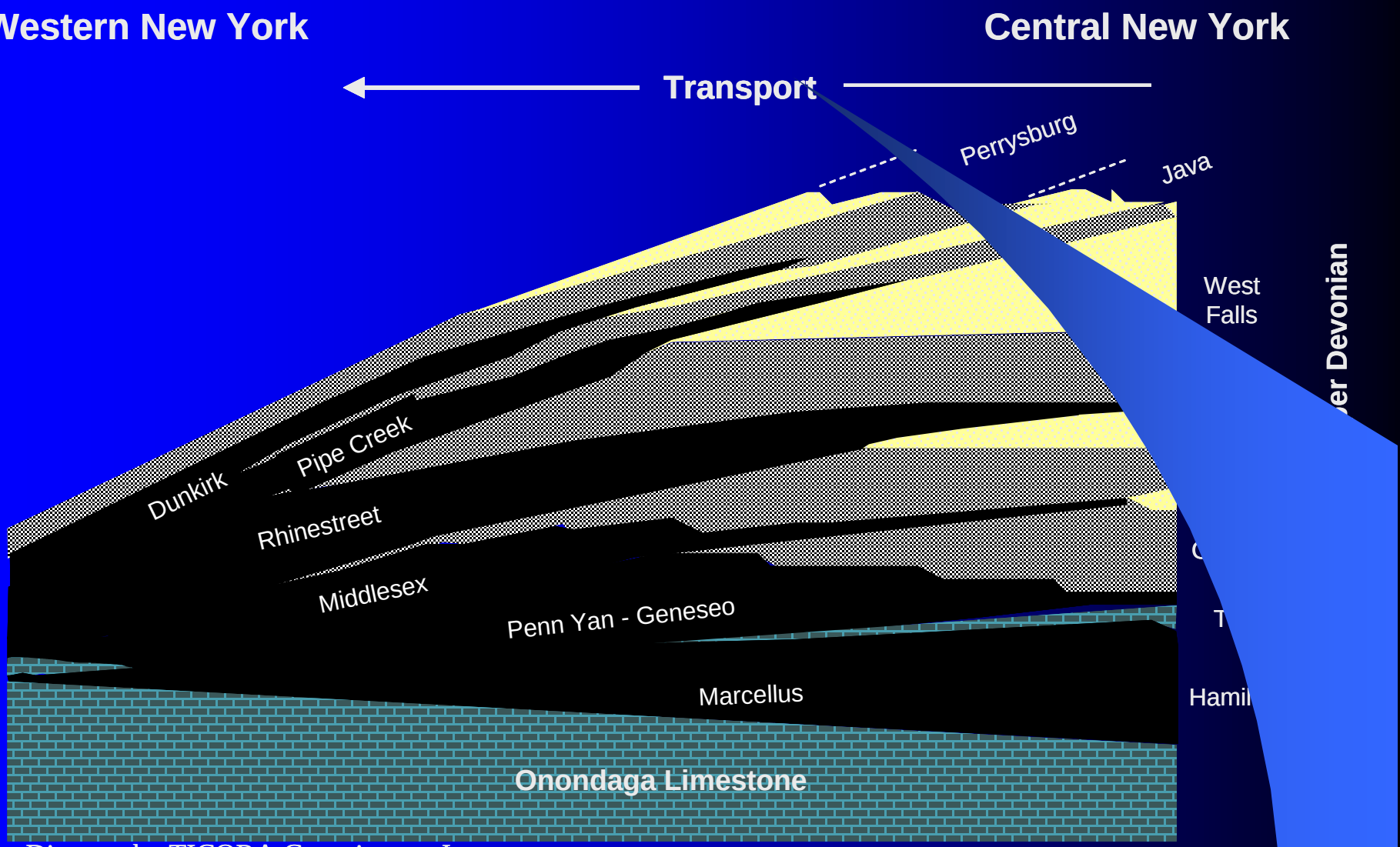
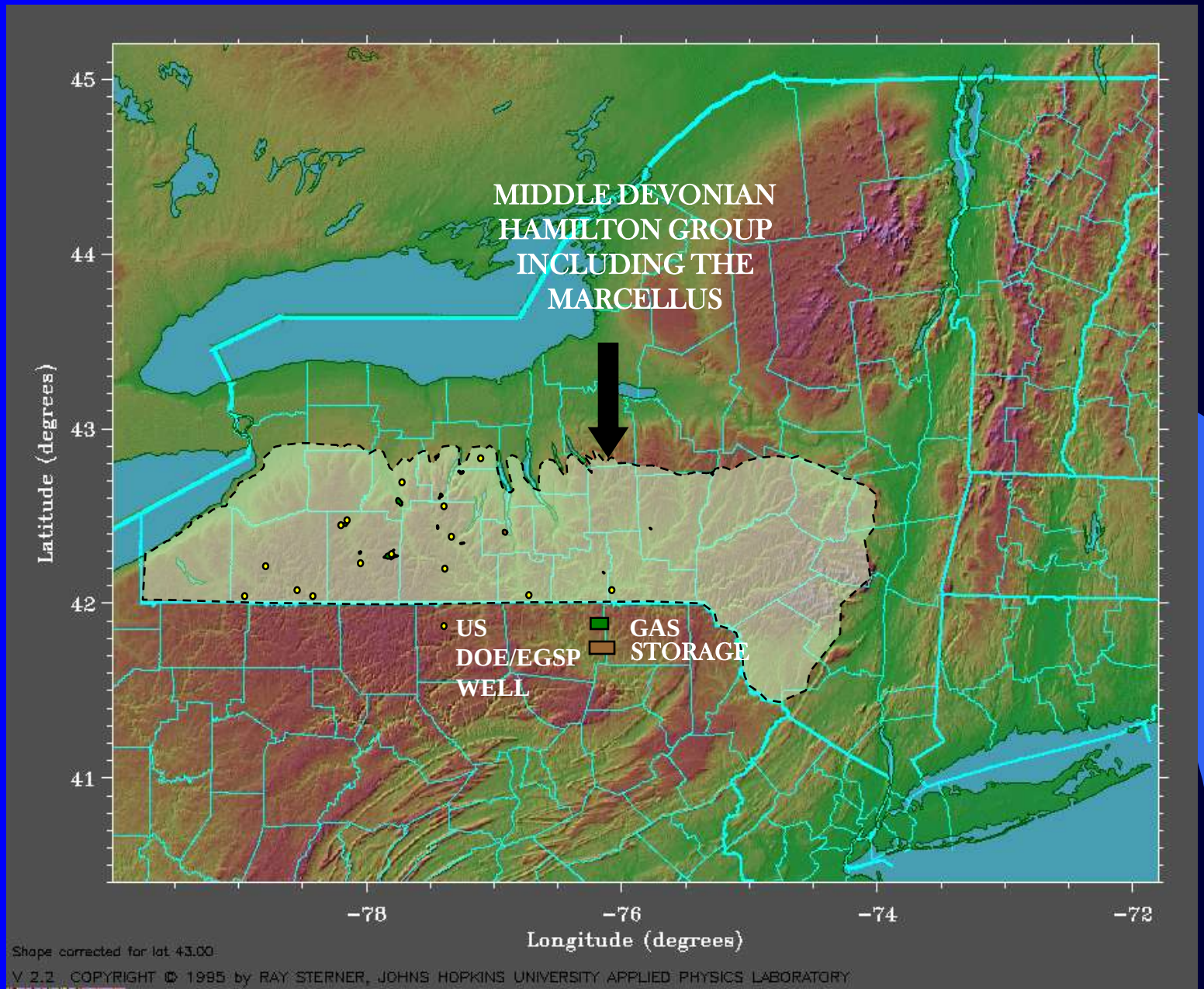


Diagram by TICORA Geosciences, Inc.

Extent Of Middle Devonian Shale



Marcellus Shale Outcrops

City View Terrace, off N.Y. Rte. 28, northwest of Kingston, NY

U.S. Rte. 20, near Cherry Valley, NY

Source: Charles Ver Straeten, NYS Museum

Good Rocks: Marcellus Fractures and Core Analysis

Naturally-fractured Marcellus

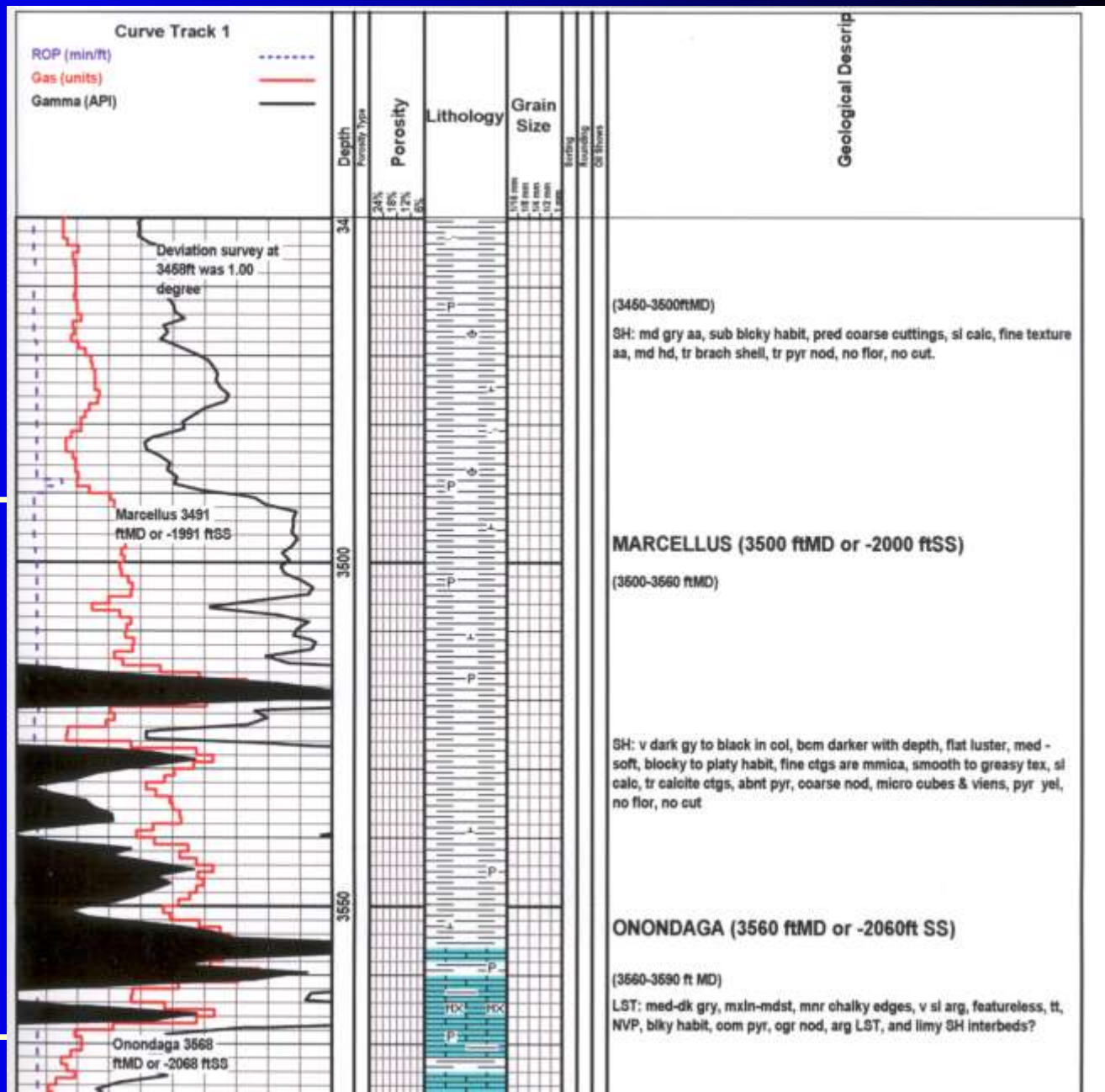
Core shows lithological heterogeneity in the Marcellus:

Source: NYSM, 2008

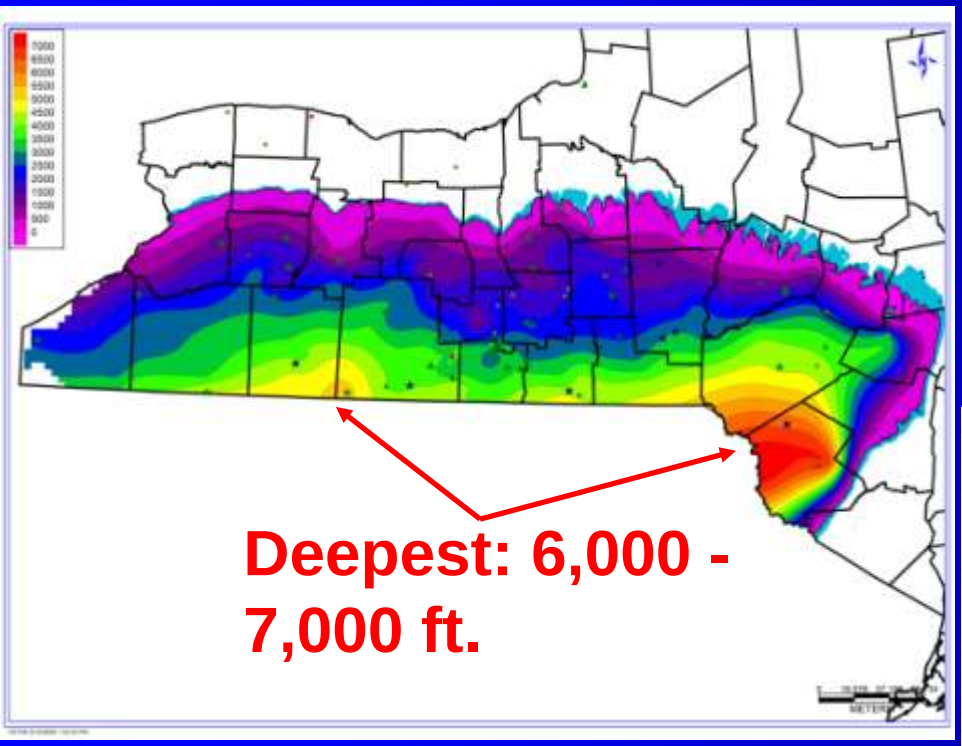
Andrews #1 Log, Steuben County

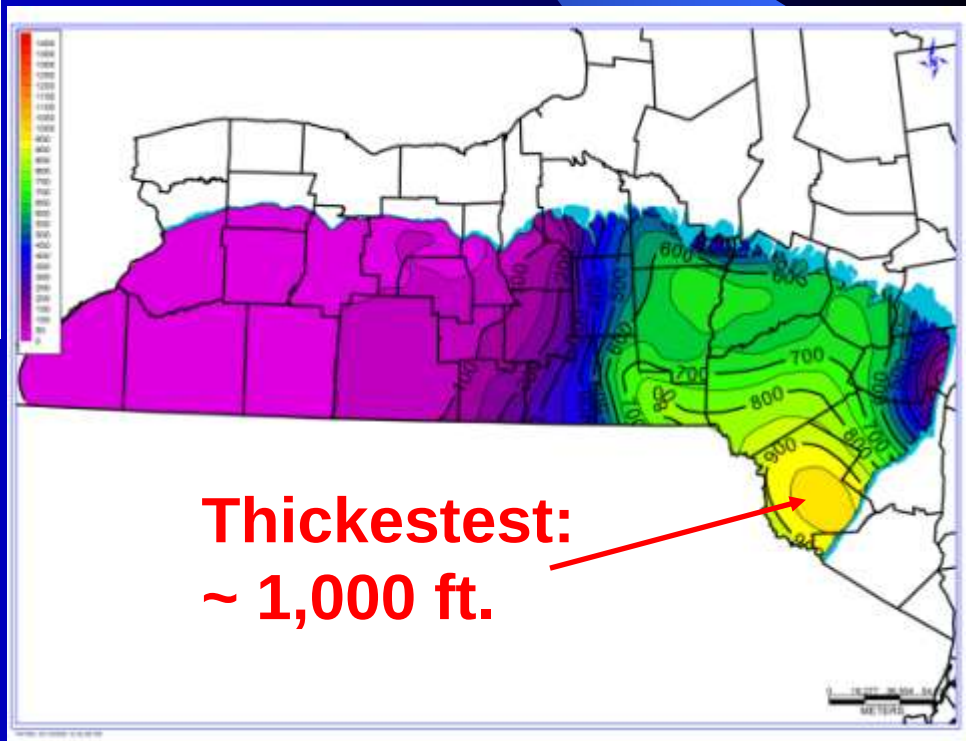
Marcellus

3,491’ to 3567’



Marcellus Depth and Thickness

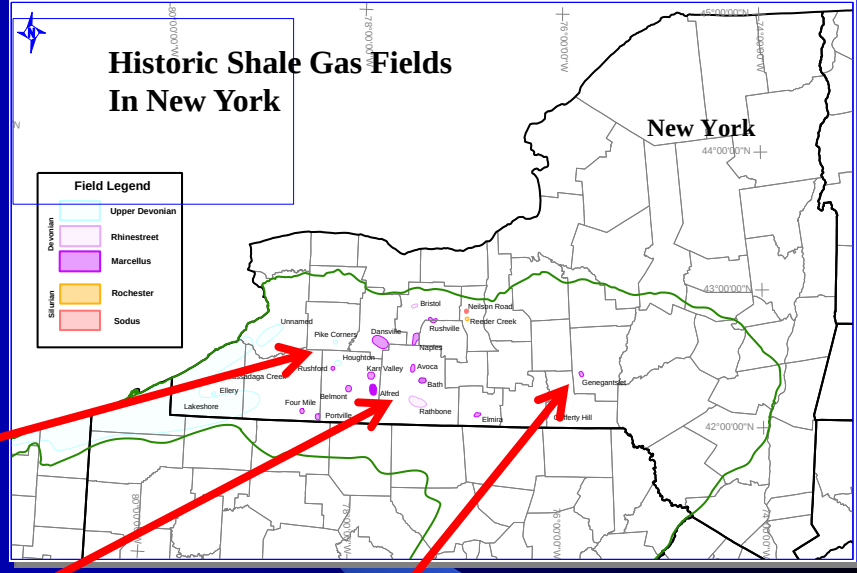




Source: NYSM, 2009

Marcellus Shale Production

New York Production History



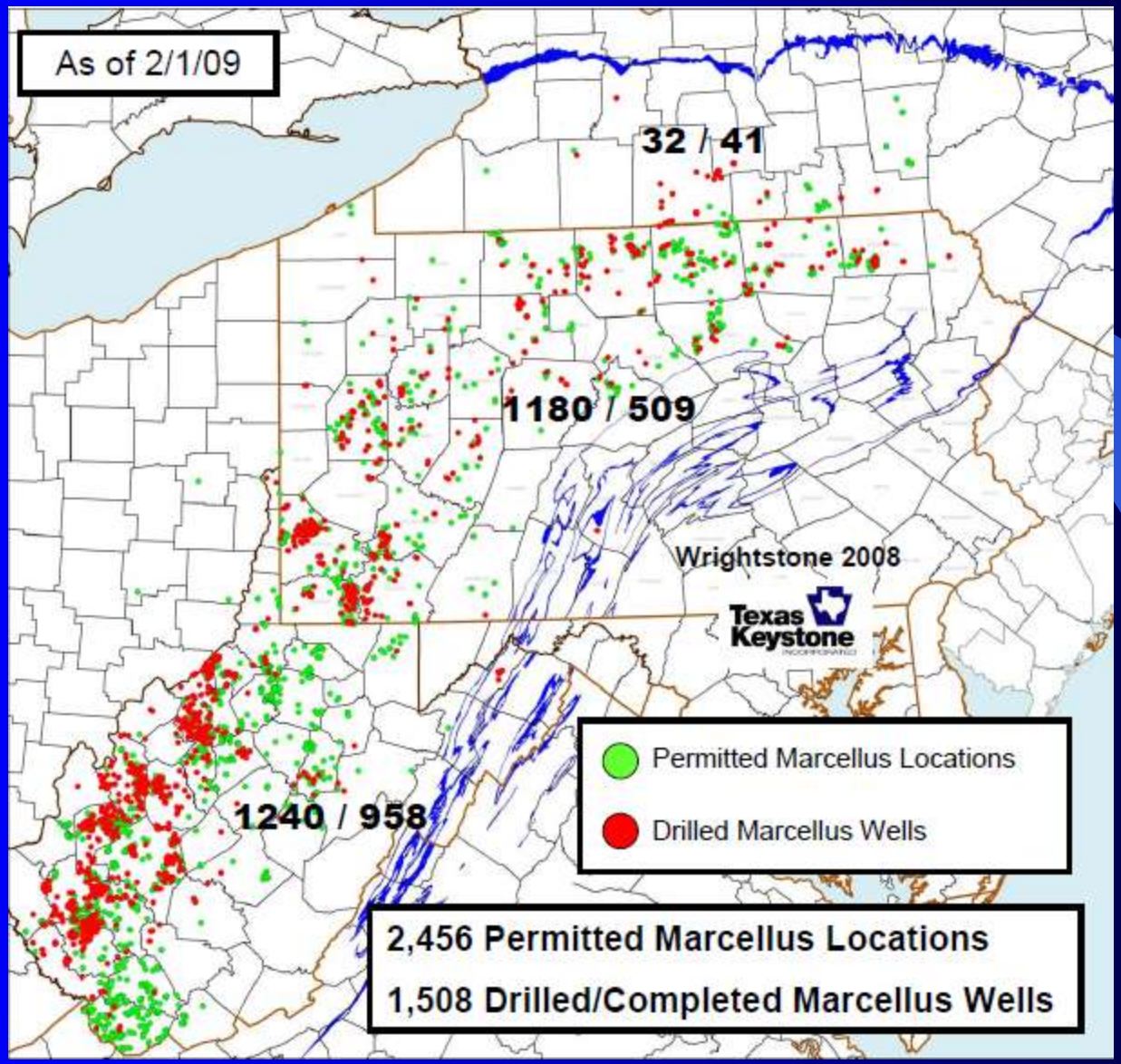
Shows/Production

- 1880s: Wells completed in Livingston, Ontario counties
- 1930s: The Rathbone Field discovery, Steuben County has a 3,300 MCF/D show, an initial open flow of 1,000 mcf/day, and a final open flow of 886 mcf/day.
- The Decker #1 well, Geneganslet Field, Chenango County, had an initial potential of 1650 MCF/D, with between 565 lbs to 650 lbs pressure.
- NYSERDA drilled a number of Devonian shale in the early 1980s to test the potential of the Marcellus and other Devonian shale formations.

Recent Activity

- A few new wells drilled in southeastern NYS as well as throughout the Appalachian Basin

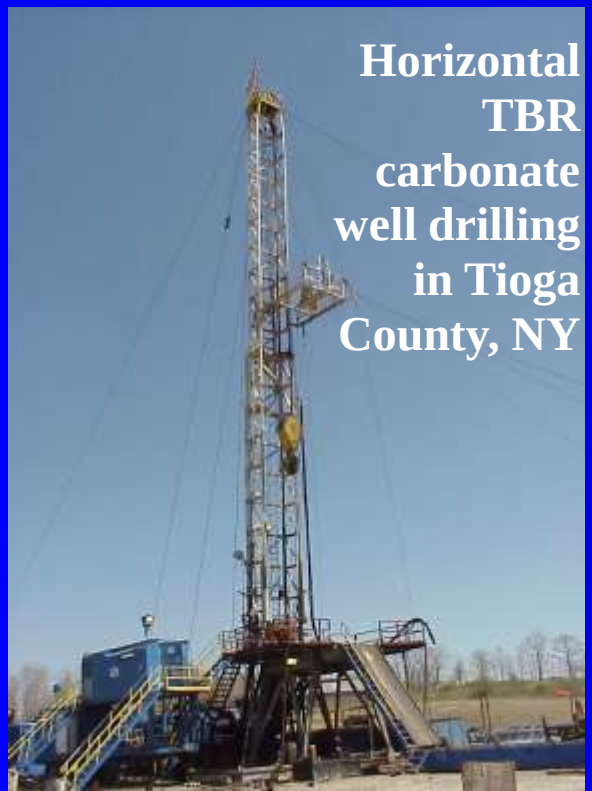
Historical and Recent Marcellus Activity

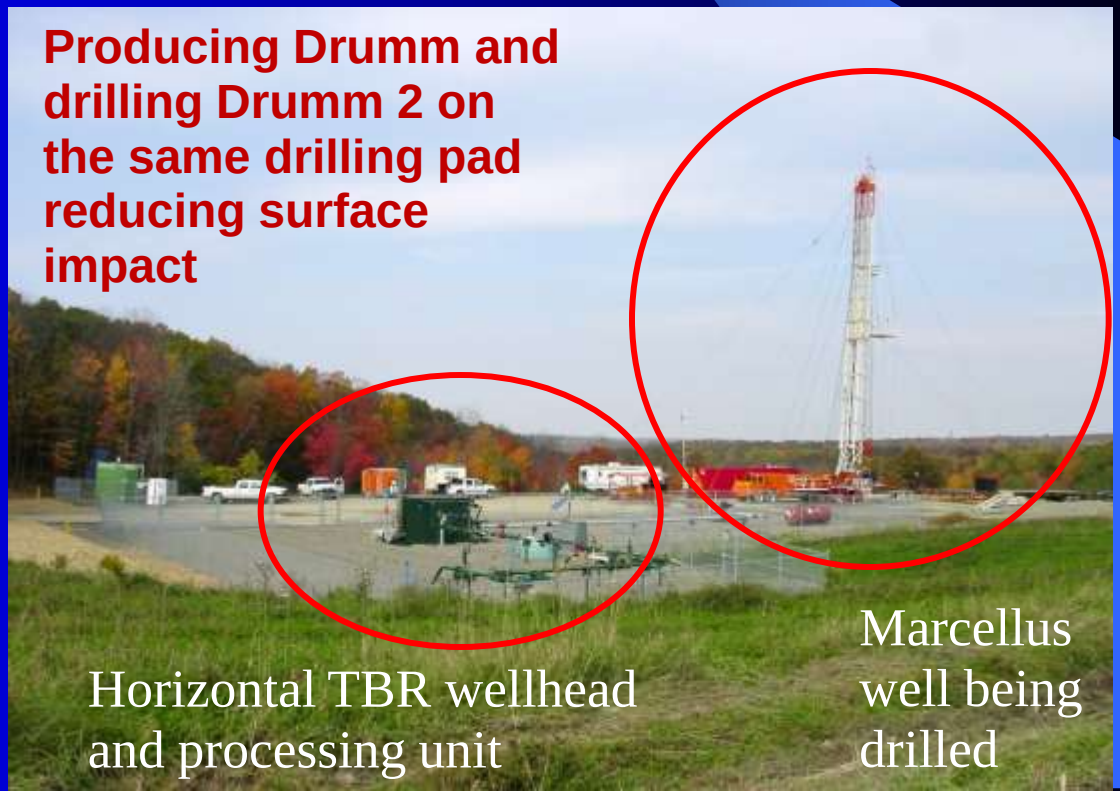


Wrightstone, Gregory, IOGAWV, Feb, 2009

Engineering Design: Extended Reach Drilling

- Replaces up to 5+ vertical wells reducing drilling costs
- First horizontal well: 1929
- First horizontal shale well: 1988 (Antrim Shale, MI)
- First NYS horizontal: 1989

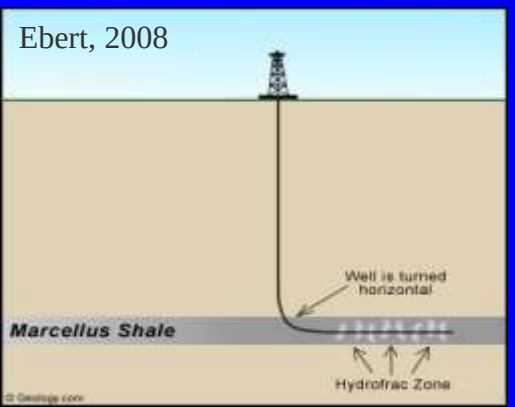




Engineering Design: Well Stimulation by Hydraulic Fracturing of Rocks

- First hydraulic fracturing: 1903 (granite mining)
- First oil and gas hydraulic frac: 1948
- Medina Sandstone (NYS): 1960s - current
- First horizontal shale well: 1995 (Barnett, TX)
- All Barnett wells stimulated (>11,000 of them!)
- Not unusual to hydraulically-fracture water wells.

Wylie, Eberhard, and Mullen, 2007



At the surface fluids and or proppants are pumped into the wellbore under high pressure to enhance production and creating areas for hydrocarbons to move from the reservoir into the well bore

USA Shale Gas Potential Resource Estimate

Potential Gas Committee (2009): 616 Tcf

Potential Resource: Appalachian Marcellus

Marcellus Recoverable Resource Estimates

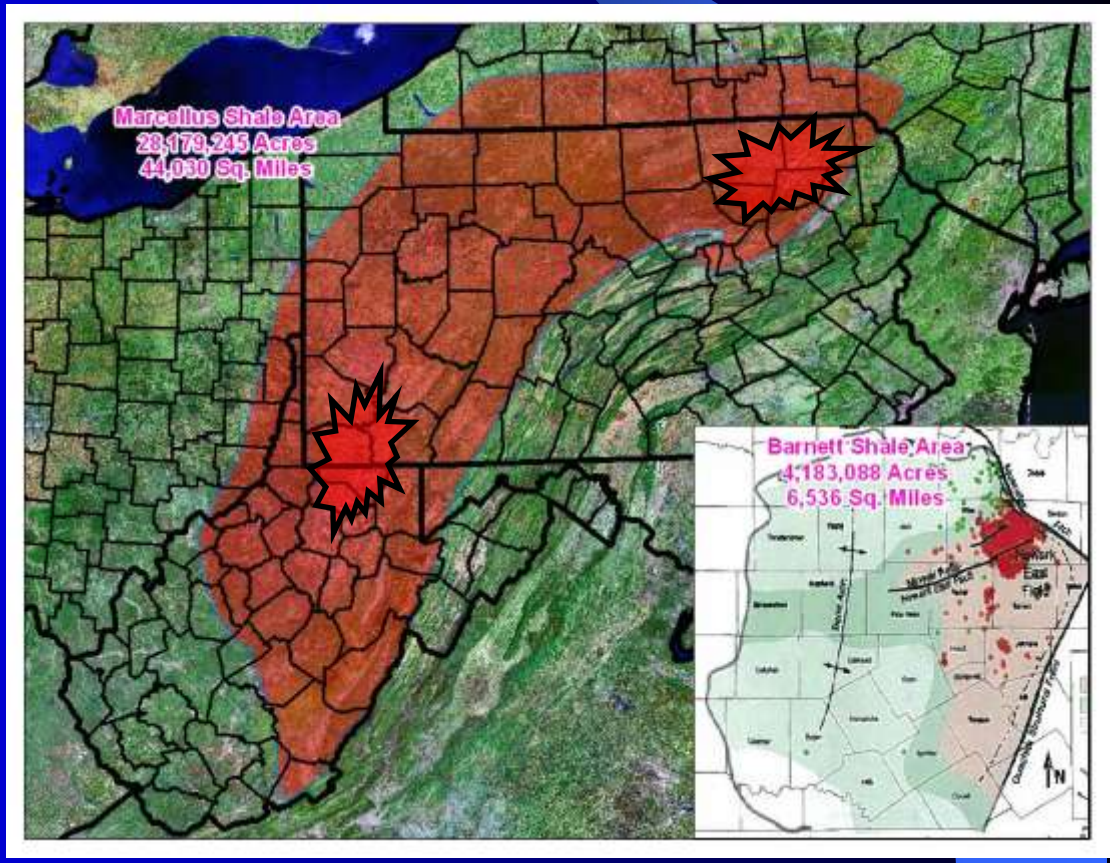
1985 Kuuskera – 67 TCF
2005 USGS Milici – 2.1 TCF
2007 - Engelder and Lash – 50 TCF
2008 - Engelder – 168 to 363 TCF
2009 - USGS – 262 TCF
2009 - Engelder – 489 TCF

Some Perspective:

Total Gas produced from Appalachian Devonian Shales before Marcellus – 3.0 TCF.

Total Gas produced from 1,000s fields from 100 separate horizons in the entire Appalachian Basin is 40 TCF to 47 TCF.

Top 15 worldwide fields have projected reserves of 50 TCF to 1,400 TCF.



Source: William Zagorski, PTTC Workshop, Erie, PA, 2009

Estimated Potential Resource: New York Marcellus and Total Devonian Shale Gas

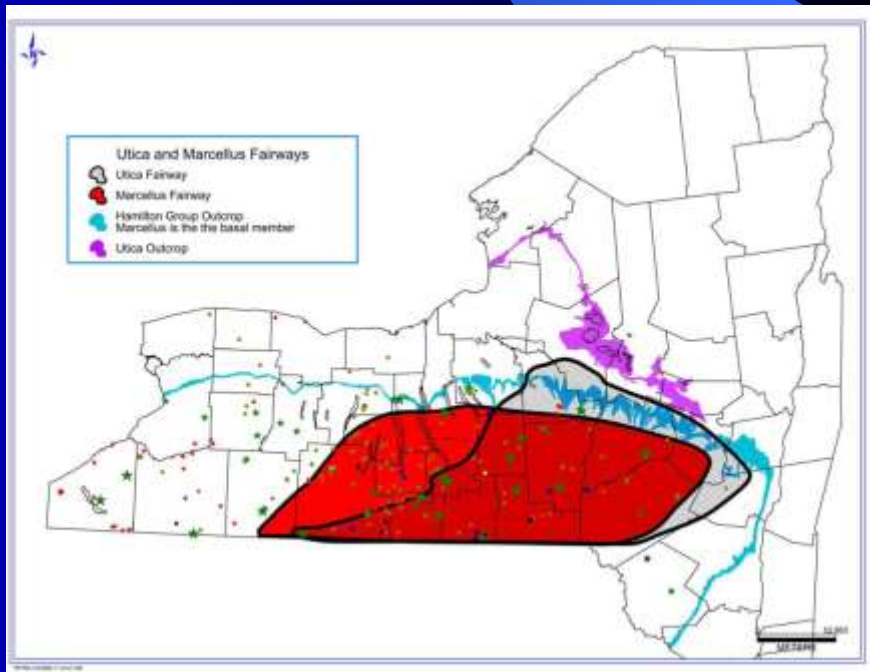
- Total Devonian Shale Resource: 163-313 Tcf
- Total Devonian Recoverable: 16.3-62.6 Tcf

- Total Marcellus Resource: 92.8 Tcf
- Total Marcellus Recoverable: 9.3-18.6 Tcf

Estimates of recoverable resources and the NYS Marcellus resource are estimates by the author. only Recoverable low estimate assumes 10% recovery factor of the lower value and high estimate assumes 20% recovery factor. Of the upper value.

Devonian Shale estimates from Hill, David G., Lombardi, Tracy E. and Martin, John P., "Fractured Shale Potential in New York," *Proceedings of the 2002 Ontario New York Oil and Gas Conference*, Ontario Petroleum Institute, London, Ontario, v. 41, 2002.

Marcellus Shale estimates derived from data provided in Milici, Robert C. Christopher S. Swezey , *Assessment of Appalachian Basin Oil and Gas Resources: Devonian Shale Middle and Upper Paleozzoic Total Petroleum System* (version 1.0), U.S. Geological Survey Open File Report 2006 1237, 2006 (calculated by 100% of plays 6, 15, 16, 19 and 50% of play 17)



NYSERDA Environmental Monitoring, Evaluation, and Protection Conference

MARCELLUS SHALE NATURAL GAS: ENVIRONMENTAL IMPACTS (DRAFT SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT (DSGEIS)) AND PROPOSED REGULATORY REQUIREMENTS

JACK DAHL
DIRECTOR BUREAU OF OIL AND GAS REGULATION
NYSDEC

Topics Covered in Today's Presentation

- SGEIS Issues
- Marcellus Lease Offers
- Proposed Drilling Permit Conditions
- SGEIS Timeline
- How to Submit Comments

Why Use a Generic EIS?

Generic Environmental Impact Statement

The Department's regulations to implement the State Environmental Quality Review Act ("SEQRA"), available at http://www.dec.ny.gov/regs/4490.html, authorize the use of generic environmental impact statements **to assess the environmental impacts of separate actions having generic or common impacts**. A generic environmental impact statement and its findings "set forth specific conditions or criteria under which future actions will be undertaken or approved, including requirements for any subsequent SEQR compliance." **When a final generic environmental impact statement has been filed, "no further SEQR compliance is required if a subsequent proposed action will be carried out in conformance with the conditions and thresholds established for such actions" in the generic environmental impact statement.**
6 NYCRR 617.10(c)
6 NYCRR 617.10(d)(1)

SGEIS Needed – Issues Not Addressed in GEIS

The SEQRA regulations require preparation of a supplement to a final generic environmental impact statement if a subsequent proposed action may have one or more significant adverse environmental impacts which were not addressed. The Department determined that some aspects of the current and anticipated application of **horizontal drilling and high-volume hydraulic fracturing warranted further review** in the context of a Supplemental Generic Environmental Impact Statement (SGEIS). This determination was based primarily upon three key factors:

(1) required water volumes in excess of GEIS descriptions

(2) possible drilling in the New York City Watershed, in or near the Catskill Park, and near the federally designated Upper Delaware Scenic and Recreational River

(3) longer duration of disturbance at multi-well drilling sites.

6 NYCRR 617.10(d)(4)

Recent Marcellus Lease Offers

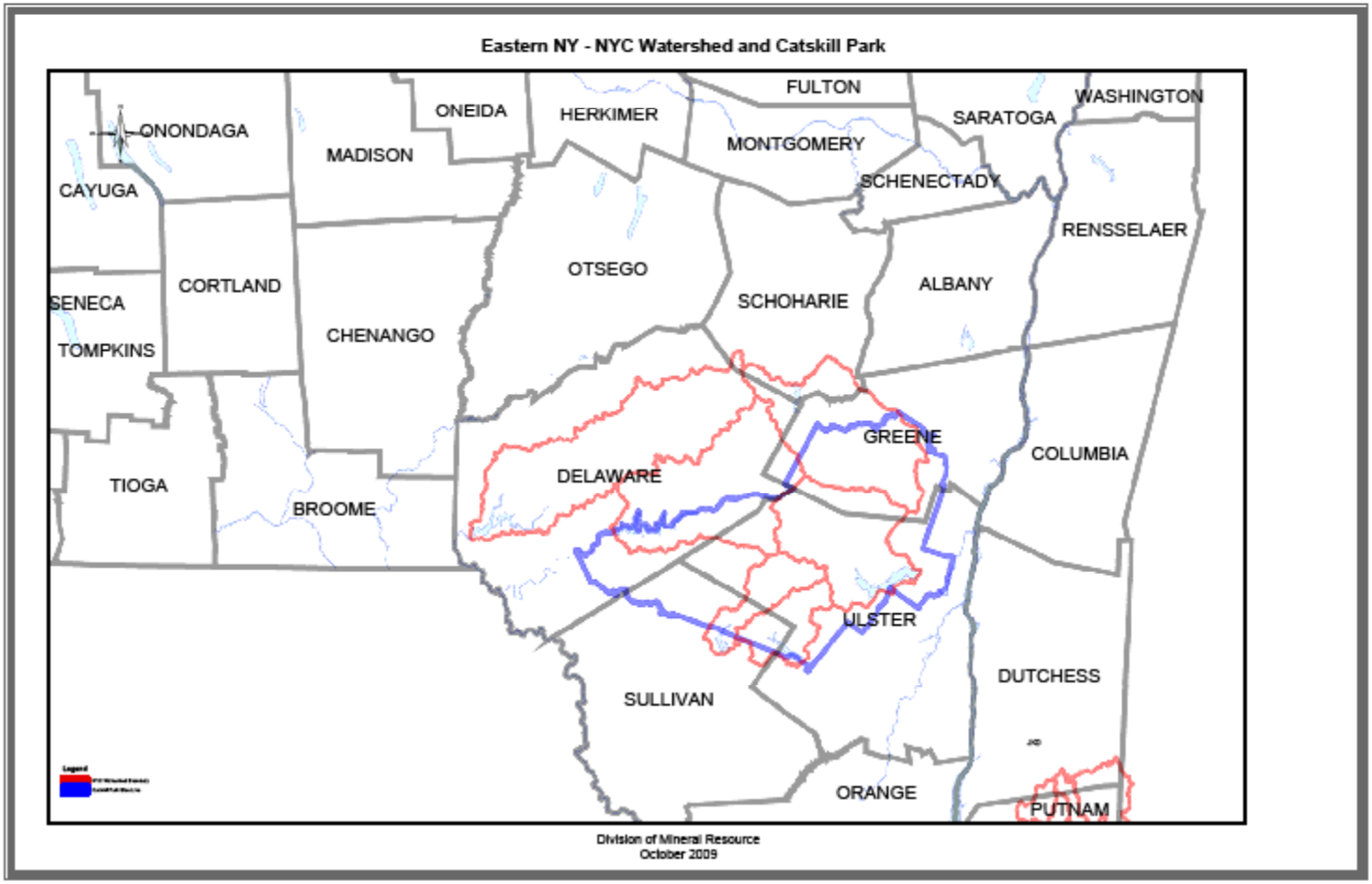
- Hess: $3,475 per acre, 20% royalty
- Fortuna: $5,500 per acre, 20% royalty
  - 30,000 acre parcel, mostly in PA
- Chesapeake: $5,750* per acre, 20% royalty

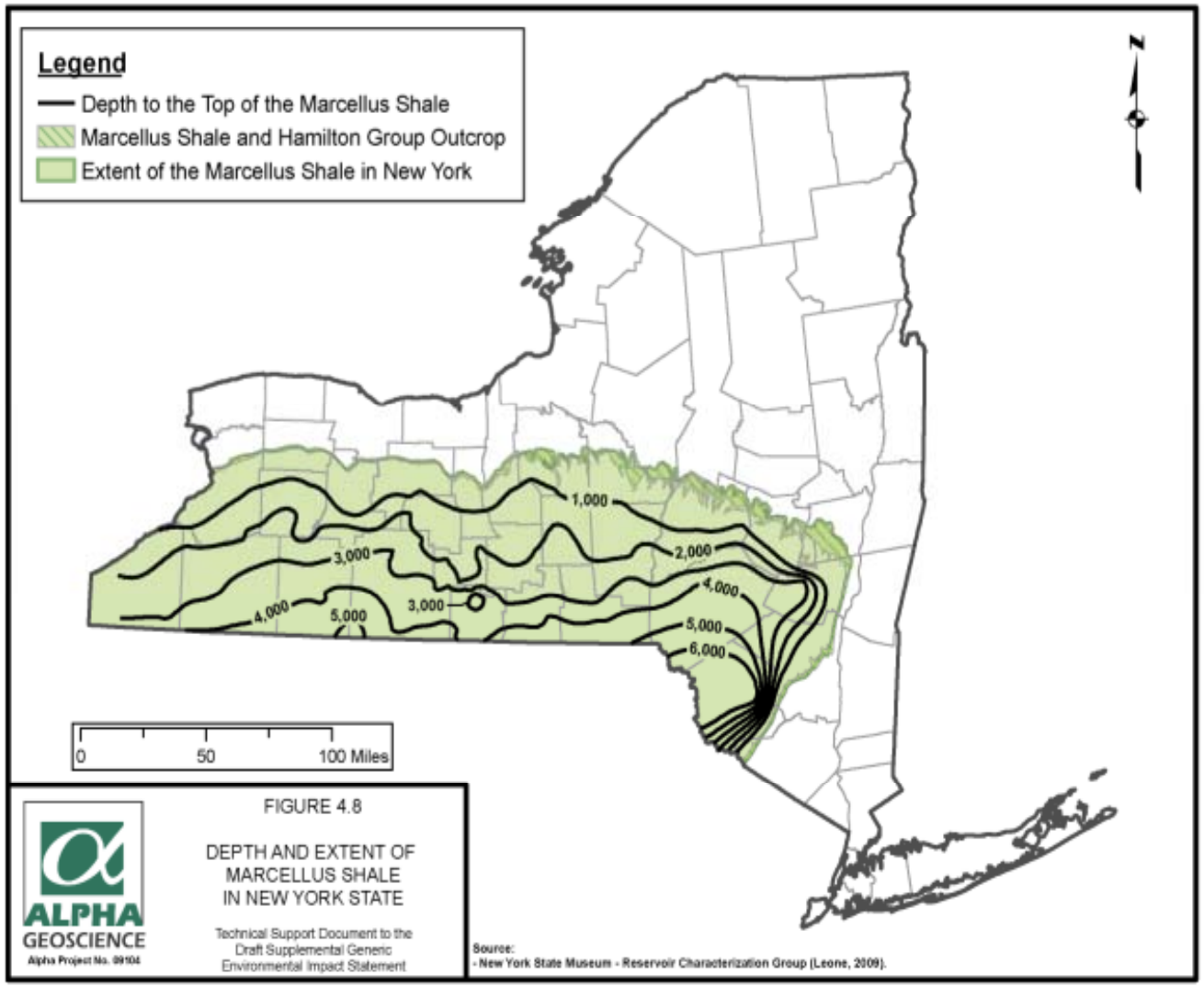
* $3.68 million per square mile

NY Counties of Highest Interest for Marcellus Exploration

- Broome
- Delaware
- Tioga
- Sullivan/Southern Chenango/Chemung

NYC Watershed and Catskill Park




Legend
Depth to the Top of the Marcellus Shale
Marcellus Shale and Hamilton Group Outcrop
Extent of the Marcellus Shale in New York
N
1,000
2,000
3,000
4,000
5,000
6,000
3,000
4,000
5,000
0
50
100 Miles
ALPHA
GEOSCIENCE
Alpha Project No. 09104
FIGURE 4.8
DEPTH AND EXTENT OF
MARCELLUS SHALE
IN NEW YORK STATE
Technical Support Document to the
Draft Supplemental Generic
Environmental Impact Statement
Source:
- New York State Museum - Reservoir Characterization Group (Leone, 2009).

Marcellus “Exploration” in Pennsylvania

Proposed High Volume Hydraulic FRAC Permit Conditions

- Planning and Local Coordination (7)
- Site Preparation (5)
- Site Maintenance (4)
- Drilling, Stimulation and Flowback (22)
- Reclamation (6)
- General (4)
- Additional Conditions

Planning and Local Coordination

- Contact County Emergency Management Office
- Road Use – trucking plan
- Sample and test water wells (private and public)
- Water well monitoring for one year after fracture operations

Site Preparation

- Stockpile topsoil
- Stormwater SPDES Permit
  - Multi-Sector General Permit: covers construction, drilling and fracturing operations
    - Coverage under MSGP must be acquired prior to issuance of drilling permit
- Pit liner specs and wellpad construction requirements

Site Maintenance

- Secondary containment for fuel tanks
- Siting of tanks
- Additional requirements for tanks located within bounds of a primary or principal aquifer

Drilling, Stimulation and Flowback

- Closed loop tank system for floodplain, no reserve pit
- Biocides must be registered with NYS
- All fracturing chemicals must be identified/submitted to the State for review prior to permit issuance
- Flowback fluids must be contained in steel tanks (no fracture flowback to lined pits)
- Subsequent fracturing operations require Department approval

Reclamation

- Fluid removal must be undertaken by a waste transporter with an approved Part 364 permit
- Testing of pit solids may be required prior to disposal
- Post-drilling reclamation requirements such as scarify well pads, replacement of topsoil, seed and mulching operations
- DEC inspections to verify reclamation

“Good”Reclamation

General

- NORM testing of Marcellus flowback and production fluids prior to removal
- Tracking system in place to identify generator of fluids, transportation from site via permitted hauler and destination facility

Additional Requirements

- Wildcat drilling conditions
- Aquifer drilling conditions
- Others as identified during pre-site inspection

SGEIS Timeline

- Collect comments from 9/30 – 11/30/09
- Public Comment Sessions (October and November)
- Evaluate comments
- Generate Final SGEIS
- Public Response Document and Findings Statement
- Issue Permits to Drill - ?/?/2010
  - 54 horizontal high volume hydraulic fracture drilling applications received to date

Send Us Your dSGEIS Comments

Comments - The public comment period will be open until November 30, 2009. The Department is offering three ways in which to submit comments. We have created an on line submission system which will allow you to write comments and tag them to your areas of concern. Attachments can also be included. You may submit e-mail comments; please include your name, e-mail or return mail address to ensure notice of the Final SGEIS when it is available.
Finally, written comments should be sent to: Attn: dSGEIS Comments, Bureau of Oil & Gas Regulation, NYSDEC Division of Mineral Resources, 625 Broadway, Third Floor, Albany, NY 12233 6500.

http://www.dec.ny.gov/energy/58440.html