

EIA Marcellus Shale Play Map*

Olga H. Popova¹, Margaret Coleman², Evan Frye², Gary Long², and Elizabeth Panarelli²

Search and Discovery Article #10767 (2015)

Posted August 24, 2015

*Adapted from oral presentation given at AAPG Annual Convention & Exhibition, Denver, Colorado, May 31-June 3, 2015

¹US DOE, EIA, Washington, District of Columbia, United States (olga.popova@eia.gov)

²US DOE, EIA, Washington, District of Columbia, United States

Abstract

The U.S. Energy Information Administration is updating maps of major tight oil and shale gas plays of the lower 48 states including the Marcellus Shale of the Appalachian Basin. The revised Marcellus play map summarizes geologic play elements, the growth of production, and distribution of sweet spots within the play based on publicly available data and a commercial well information database. The Middle Devonian Marcellus Shale was deposited during the early stages of mountain building events in a foreland basin. The Marcellus Shale disconformably overlies the Onondaga Limestone and is composed of a basal black shale, a widespread limestone unit, and an upper black shale. Key geologic drivers defining the most prospective areas within the Marcellus Shale footprint are comparable to other shale-gas plays and consist of an optimal combination of structural, geochemical, petrophysical, and thermodynamic characteristics. From 2004 through July 2014 more than 7000 wells targeting the Marcellus Shale were drilled in the Appalachian Basin (Drilling Info, Inc). Reported natural gas production from the Marcellus play is more than 15 billion cubic feet per day (Bcf/d), accounting for almost 40% of U.S. shale gas production as of July 2014 (EIA, 2014). For the Marcellus play, the geologic elements presented include contoured elevation of the top and base of formation, isopach, major structures and tectonic features, play boundaries, well locations, and gas-to-oil ratios of producing wells. Additional map layers will be added as additional geologic data becomes available.

References Cited

EIA, 2014, Annual Energy Outlook 2014 – With Projections to 2040: U.S. Energy Information Administration, Washington, D.C., 269 p.

Pool, S., R. Boswell, J.E. Lewis, and J.P. Mathews, 2013, A Preliminary Geology-Based Natural Gas Resource Assessment of the Marcellus Shale for West Virginia: Conference Proceedings, AAPG Annual Convention and Exhibition Pittsburgh, PA.

Popova, O.H., M.J. Small, K. Carter, S.T. McCoy, A.C. Thomas, S. Rose, B. Karimi, and A. Goodman, 2014, Spatial Stochastic Modeling of Sedimentary Formations to Assess CO₂ Storage Potential: Environmental Science and Technology, 48/11, p. 6247-6255.

Websites Cited

EIA Online Maps. http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm

Shale Gas and Tight Oil Plays in the Lower 48 States: U.S. Energy Information Administration, based on data from various published studies, Updated April 14, 2015. http://www.eia.gov/oil_gas/rpd/shale_gas.pdf

Shale Gas and Tight Oil Plays in the Lower 48 States by Geologic Age: U.S. Energy Information Administration, based on data from various published studies, Updated April 13, 2015. <http://www.eia.gov/todayinenergy/detail.cfm?id=20852>

Structure Map of the Marcellus Formation (Subsea Depth), Map includes production wells (7,894) from January 2003 through December 2014: U.S. Energy Information Administration. <http://www.eia.gov/todayinenergy/detail.cfm?id=20612>

EIA Marcellus Shale Play Map

*by Olga Popova (PhD), Gary Long, Evan Frye,
Margaret Coleman (PhD), and Elizabeth Panarelli*

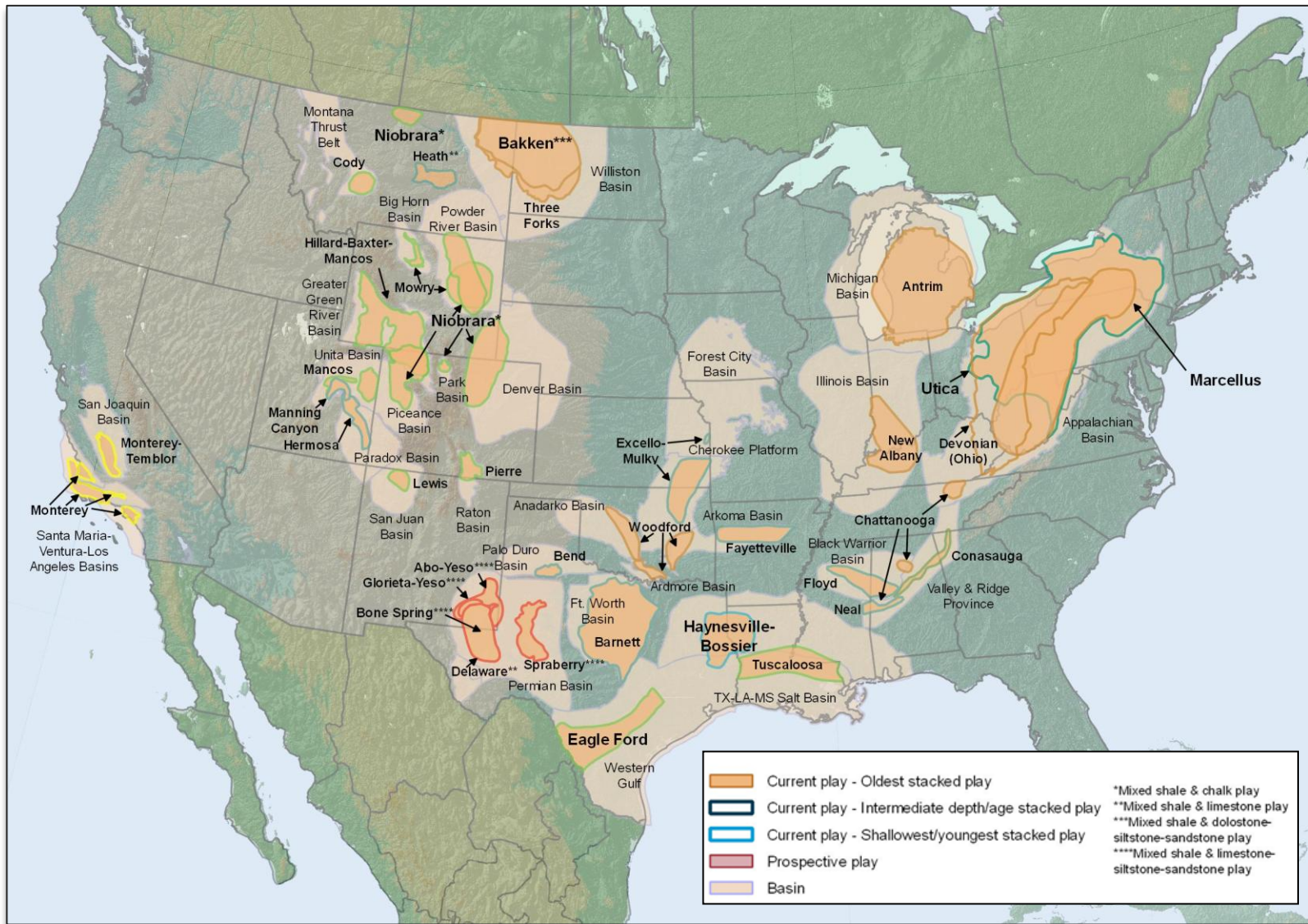


AAPG 2015 Annual Convention & Exhibition
May 31-June 3, 2015, Denver, Colorado



- Overview
- Dataset
- Marcellus maps for model development
- Next steps

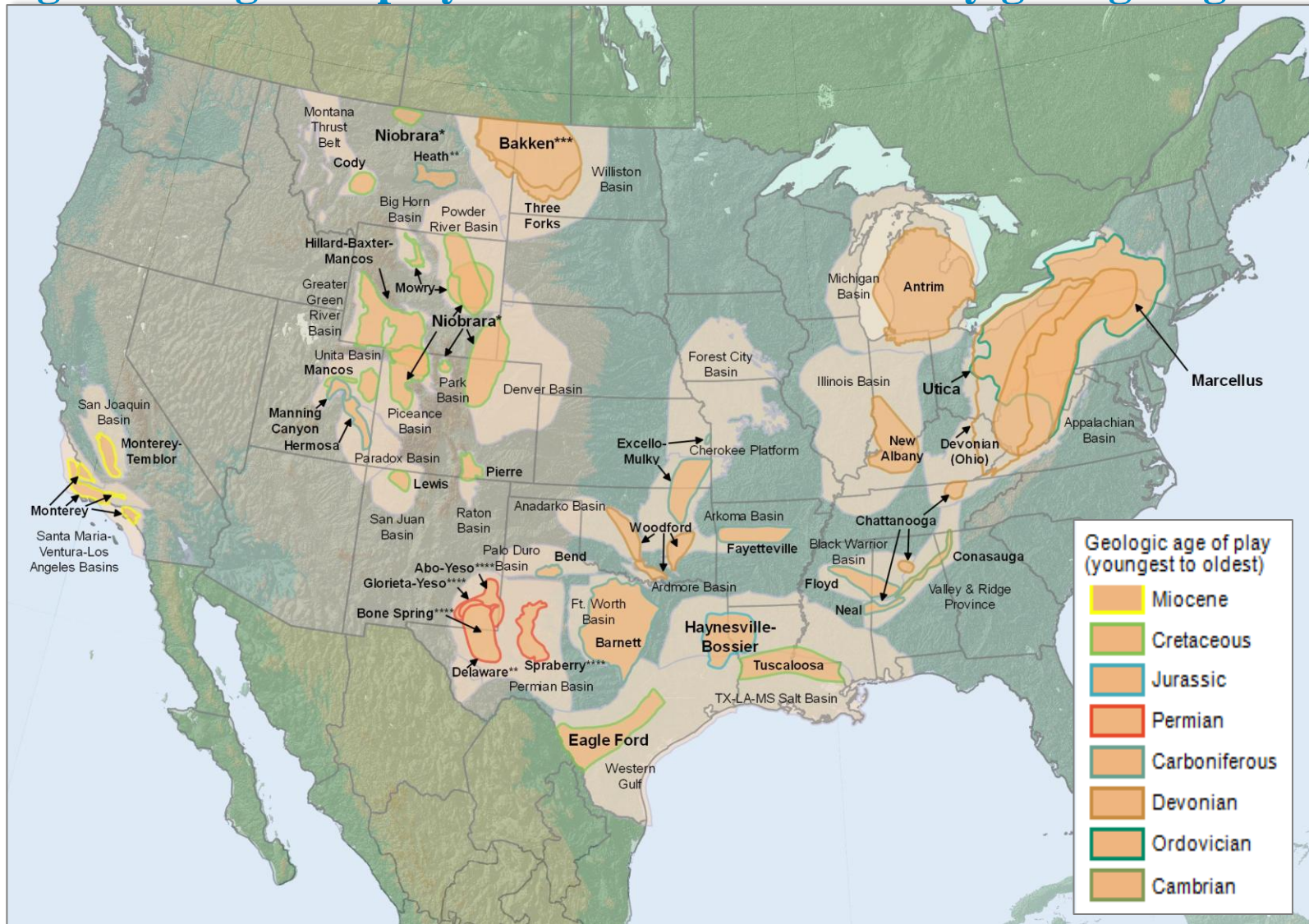
Shale gas and tight oil plays in the lower 48 states



Source: U.S. Energy Information Administration, based on data from various published studies

http://www.eia.gov/oil_gas/rpd/shale_gas.pdf | Updated April 14, 2015

Shale gas and tight oil plays in the lower 48 states by geologic age



Source: U.S. Energy Information Administration, based on data from various published studies

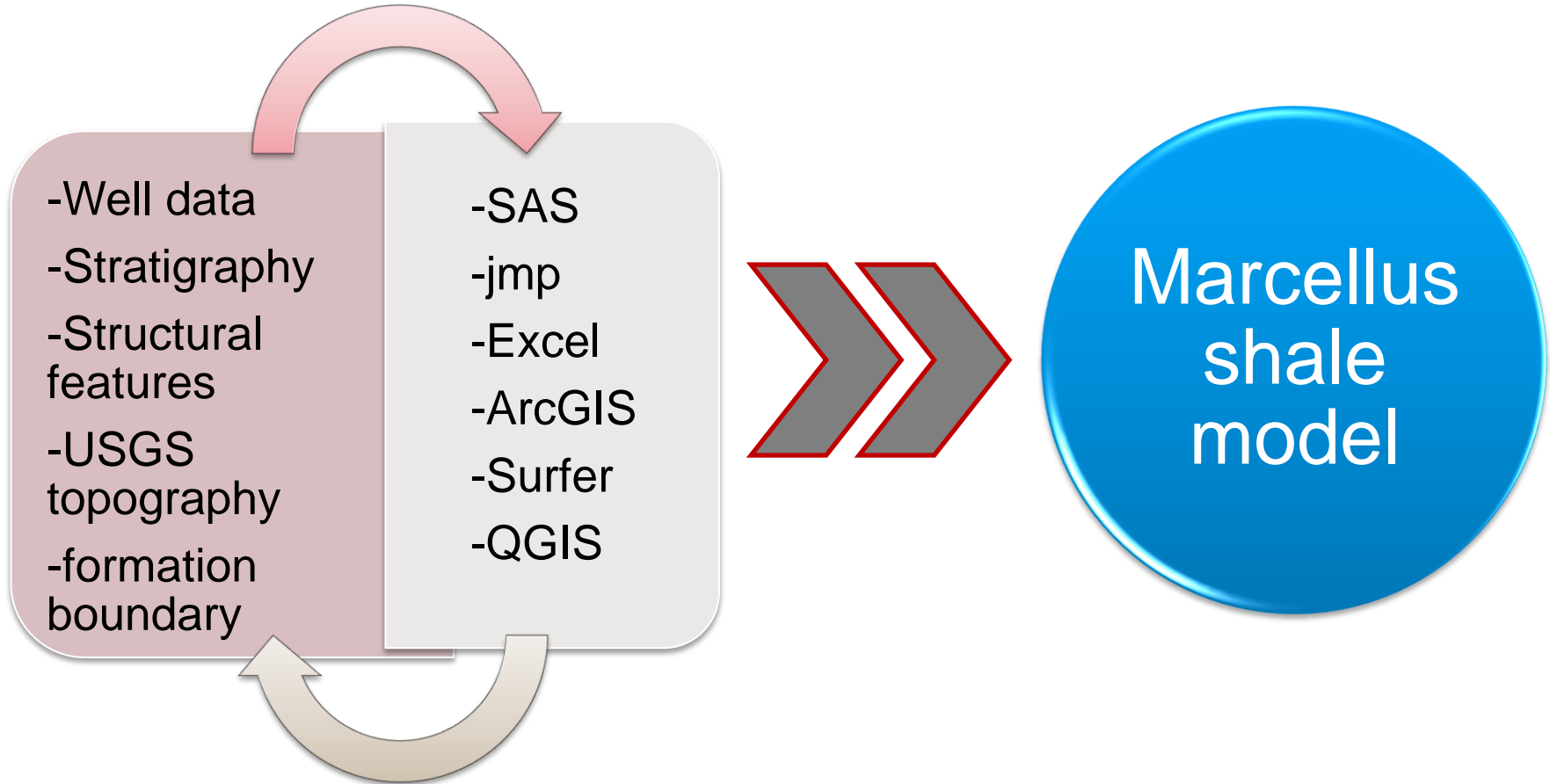
<http://www.eia.gov/todayinenergy/detail.cfm?id=20852> | Updated April 13, 2015

Datasets for the Marcellus shale

- DI (DrillingInfo) well data
- State well data (PA, OH, NY, and WV)
- Published articles and information provided by State agencies on stratigraphy, lithology, tectonics, and petrophysical properties

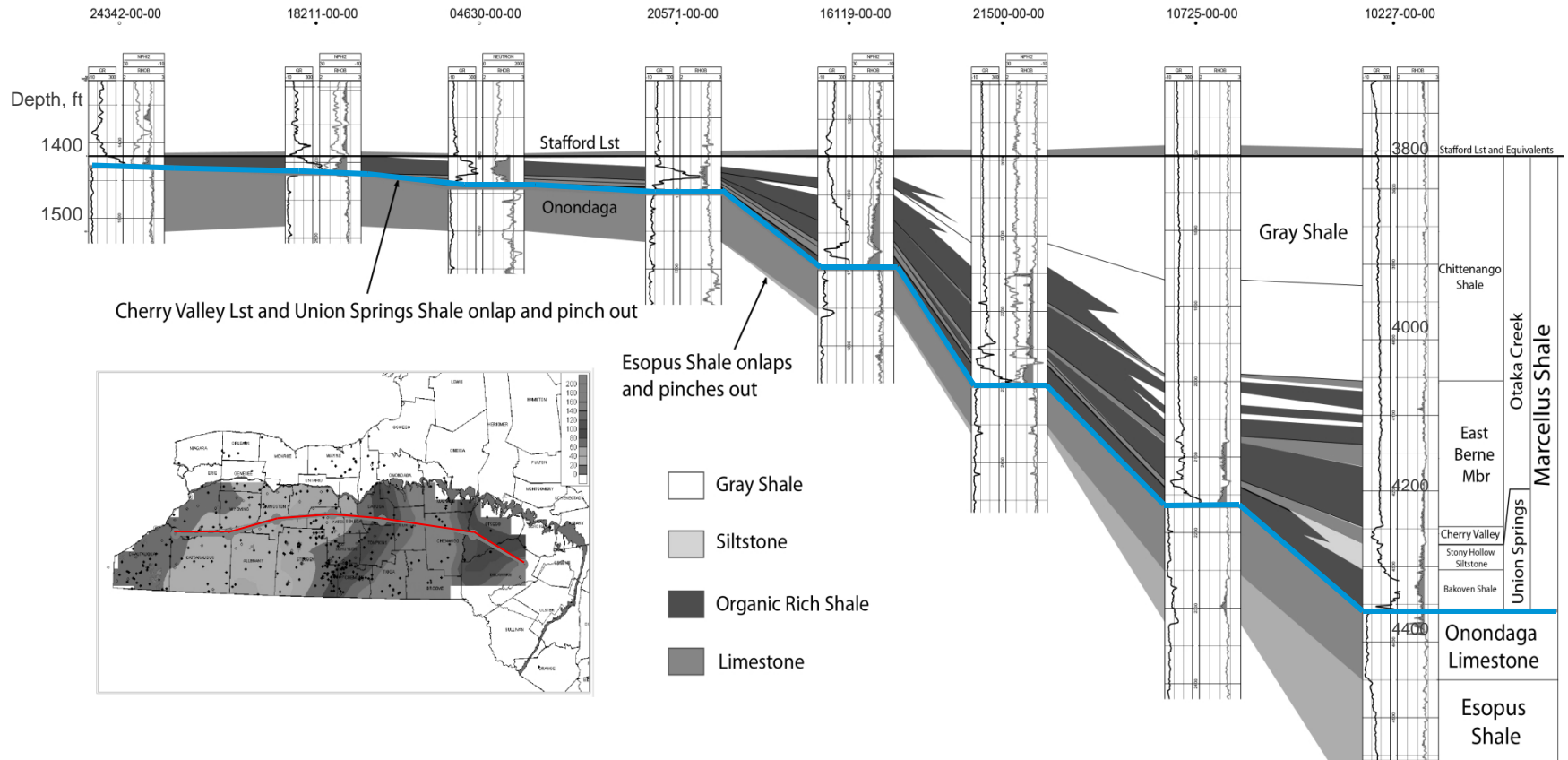
We integrated EIA research with DI and State well data and prepared a combined dataset for Marcellus

Datasets and Applications



Geologic cross section through the Appalachian Basin, NY

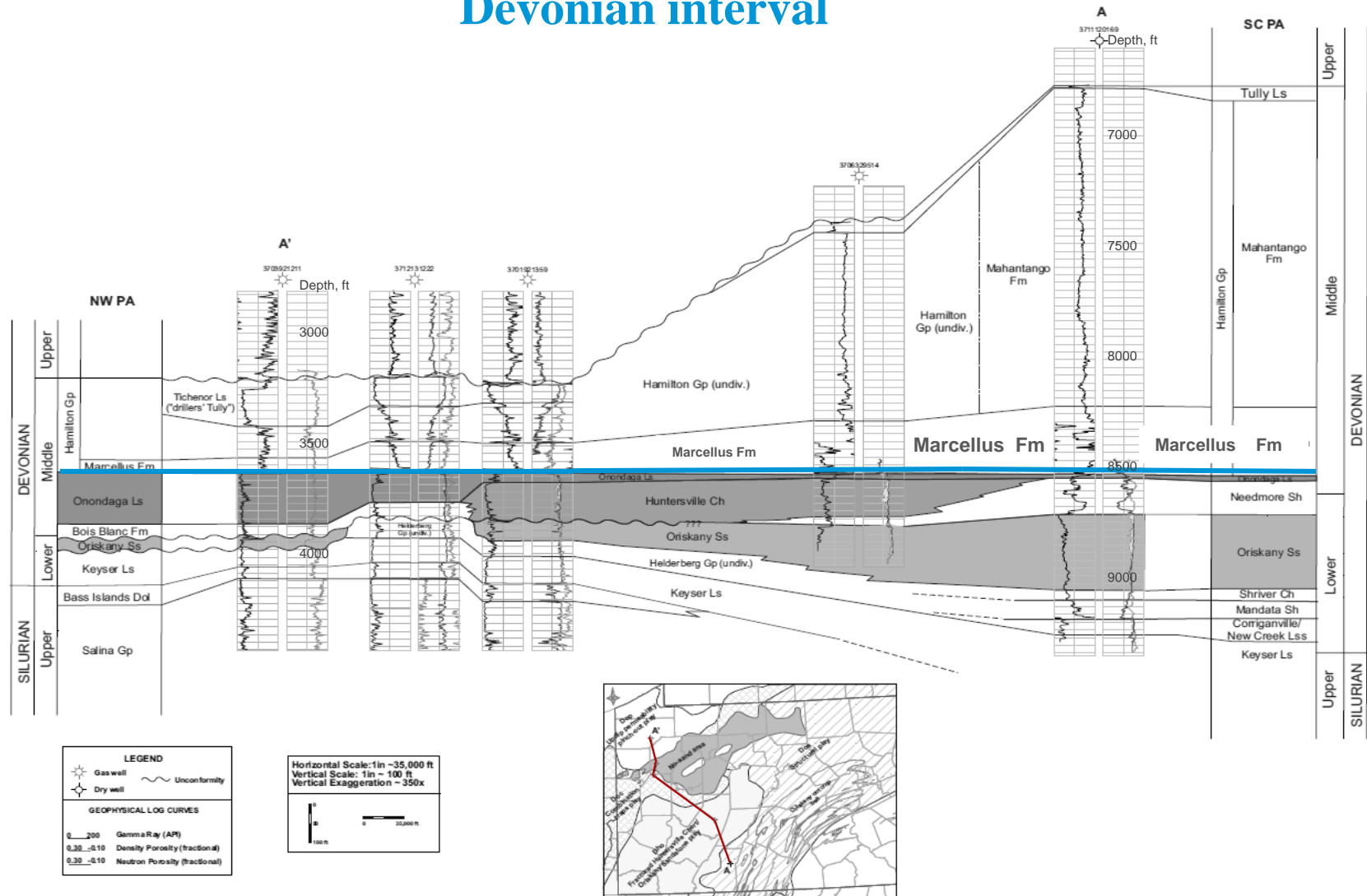
Devonian interval



Source: Taury Smith and Jim Leone, New York State Geological Survey

Geologic cross section through the Appalachian Basin, PA

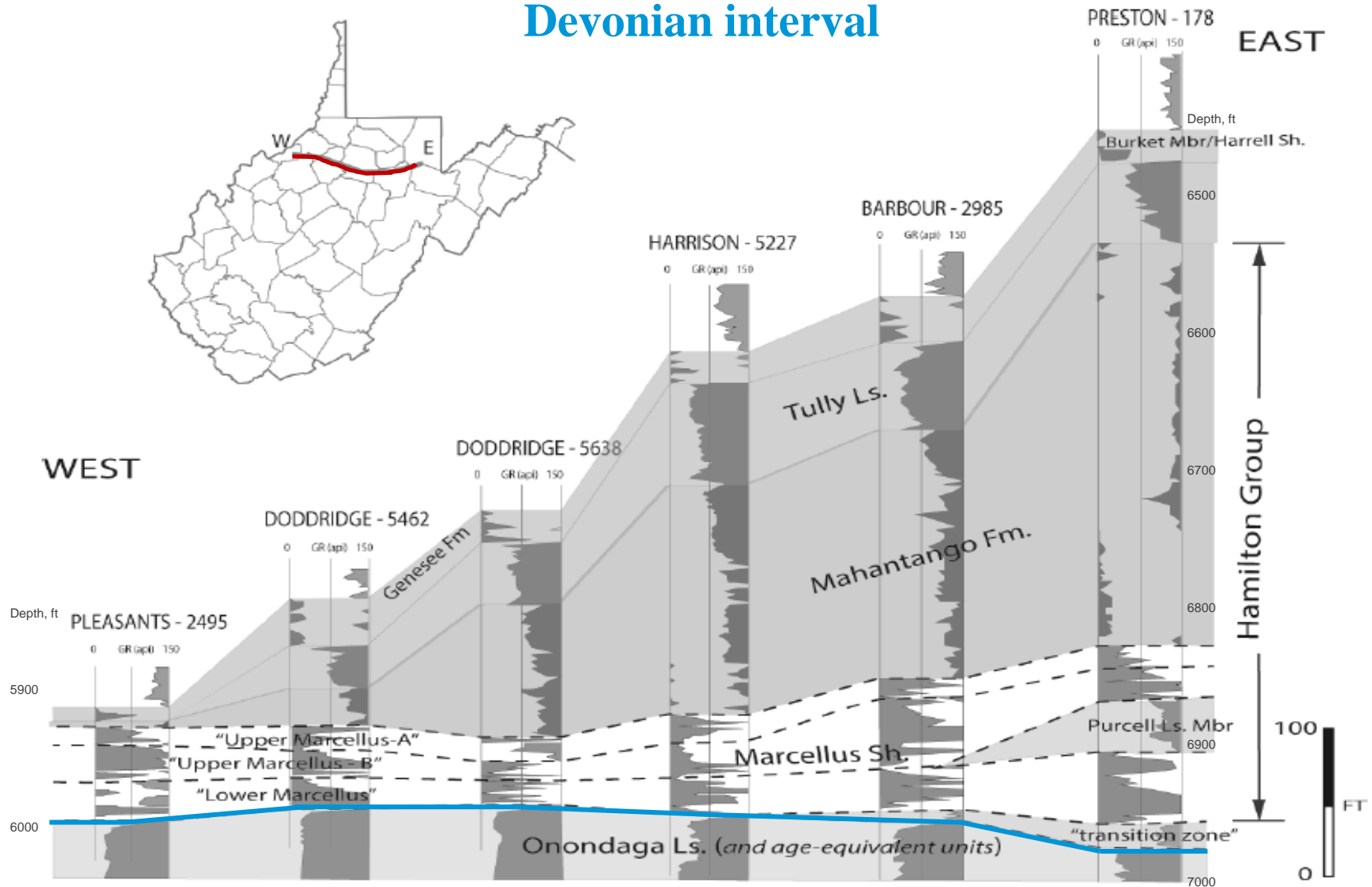
Devonian interval



Source: Popova, O. H., Small, M. J., Kristin Carter, at all., 2014. Spatial Stochastic Modeling of Sedimentary Formations to Assess CO₂ Storage Potential, ES&T, 48(11), 6247-6255.

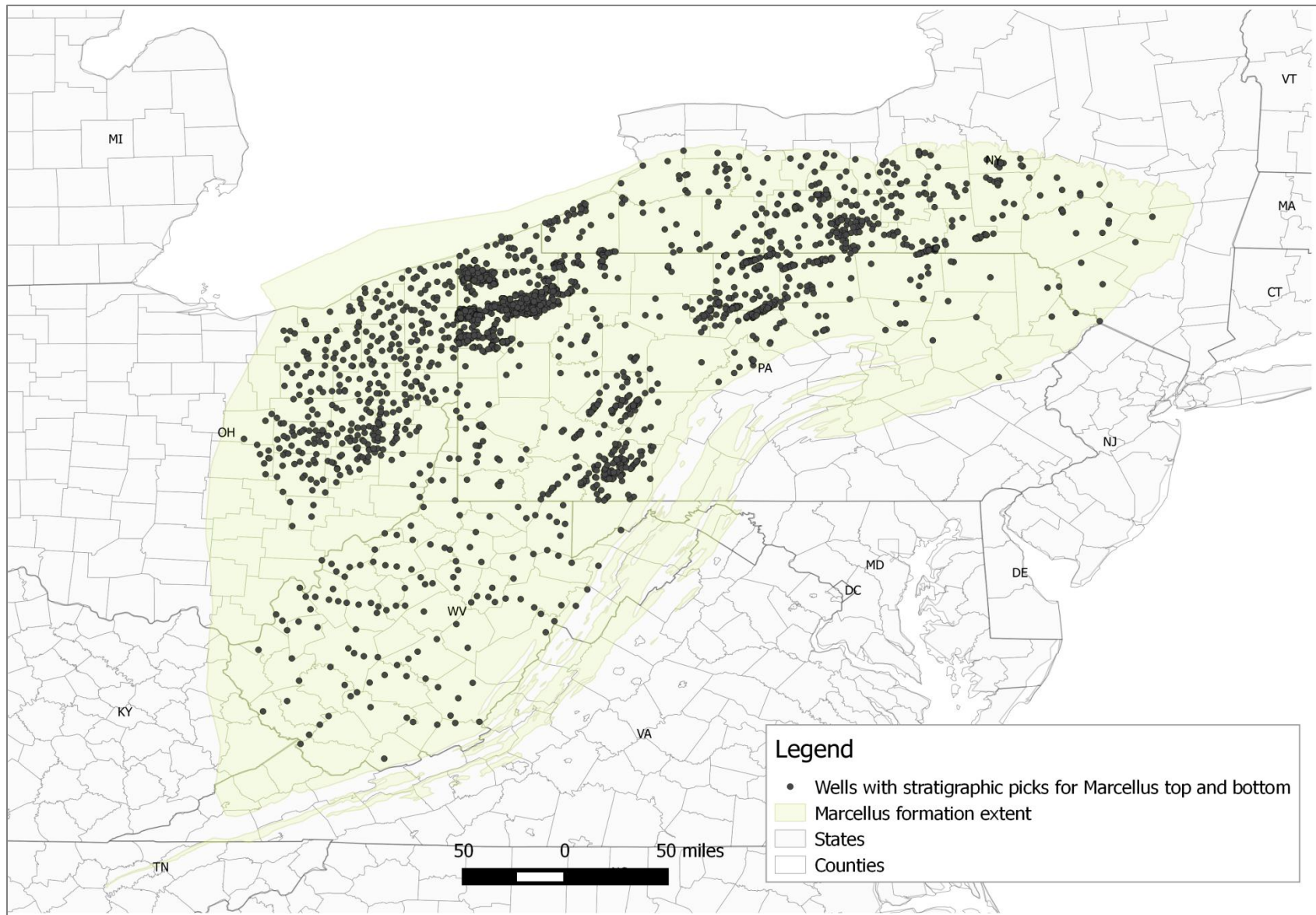
Geologic cross section through the Appalachian Basin, WV

Devonian interval



Source: Susan Pool, Ray Boswell, J. Eric Lewis, and Jonathan P. Mathews, A Preliminary Geology-Based Natural Gas Resource Assessment of the Marcellus Shale for West Virginia, West Virginia Geological & Economic Survey.

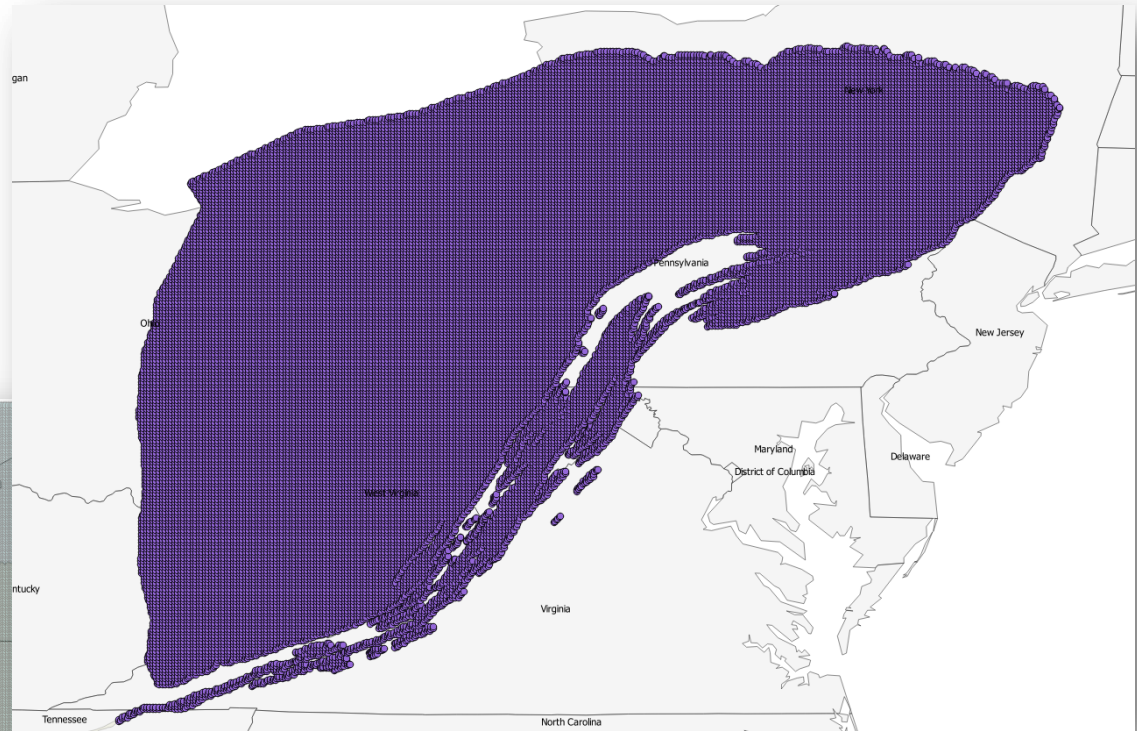
Marcellus formation (wells with stratigraphic picks)



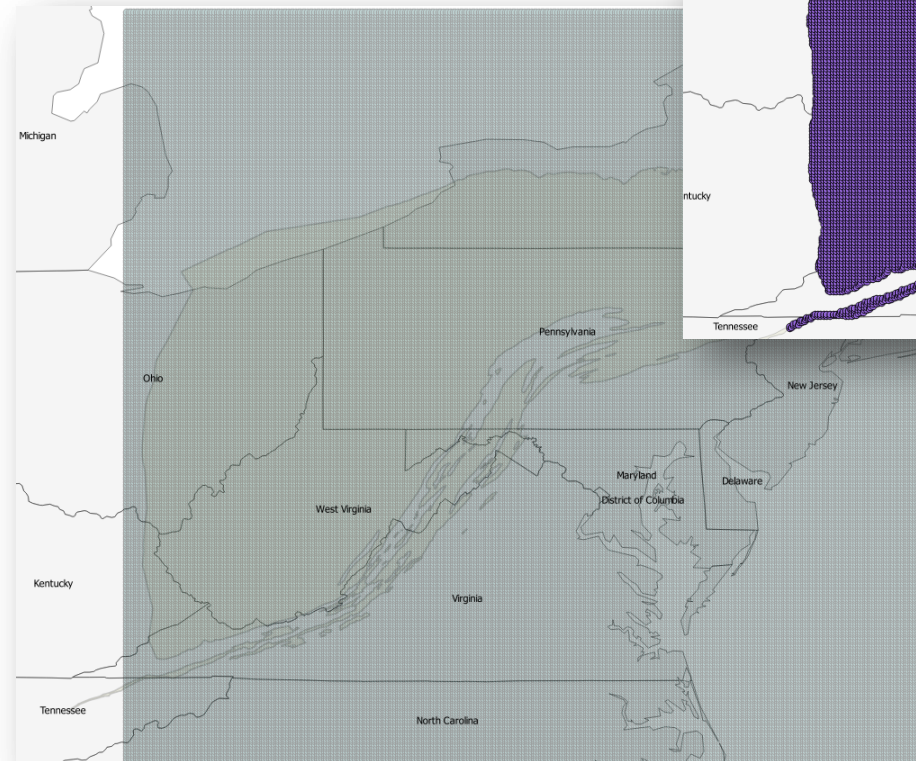
Source: U.S. Energy Information Administration, based on DrillingInfo Inc., New York State Geological Survey, Ohio State Geological Survey, Pennsylvania Bureau of Topographic & Geologic Survey, West Virginia Geological & Economic Survey, and U.S. Geological Survey

Note: EIA used stratigraphic picks from 2,416 wells for the top and bottom of the Marcellus provided directly by state geological survey agencies. These wells may not be producing from the Marcellus formation; however, these are the wells the state agencies used for their stratigraphic picks.

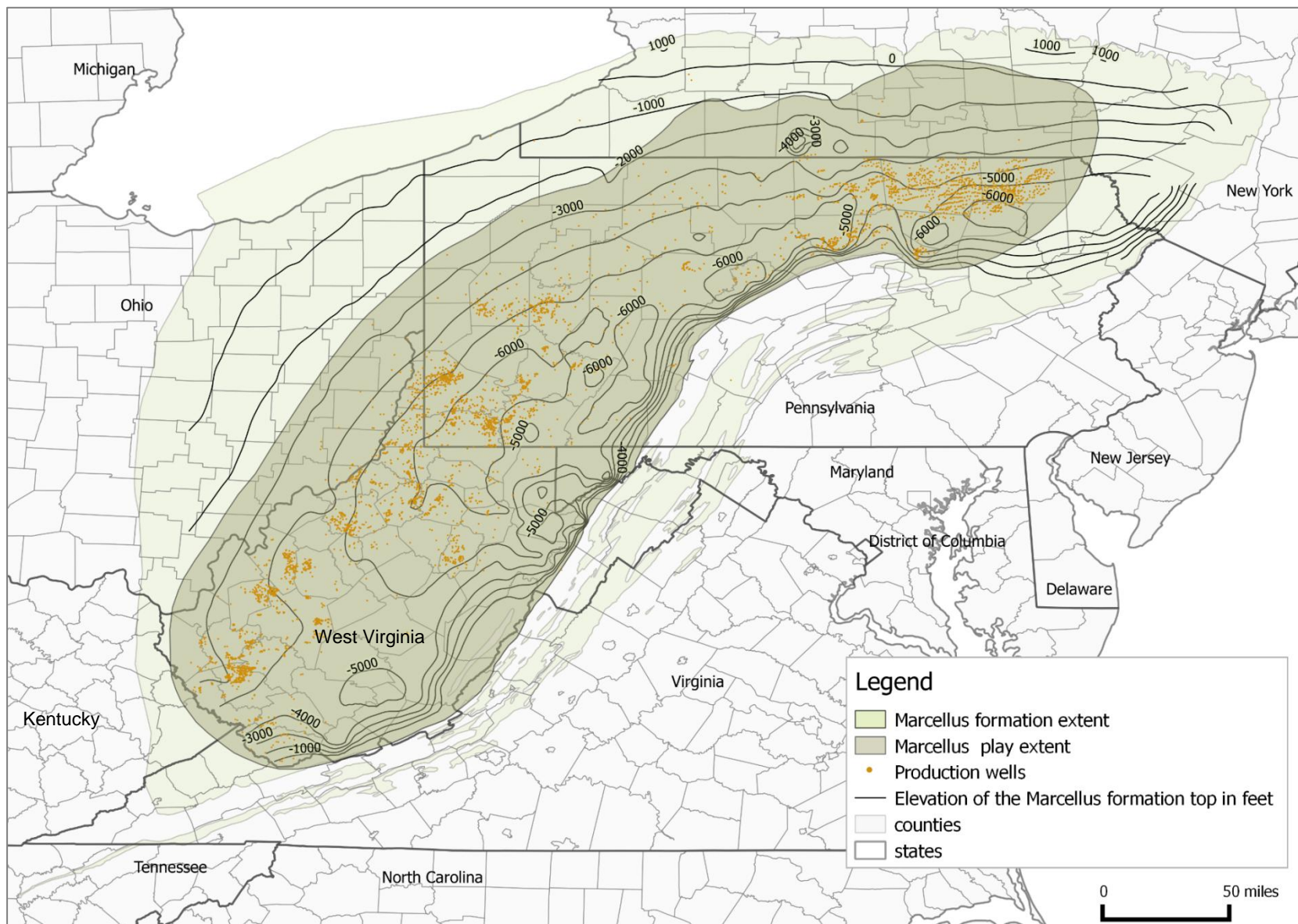
Interpolation and contouring: Surfer, QGIS, & ArcGIS



2 by 2 km grid produced by QGIS
algorithm, to acquire ArcGis
kriging raster outcome



Structure map of the Marcellus formation (subsea depth)

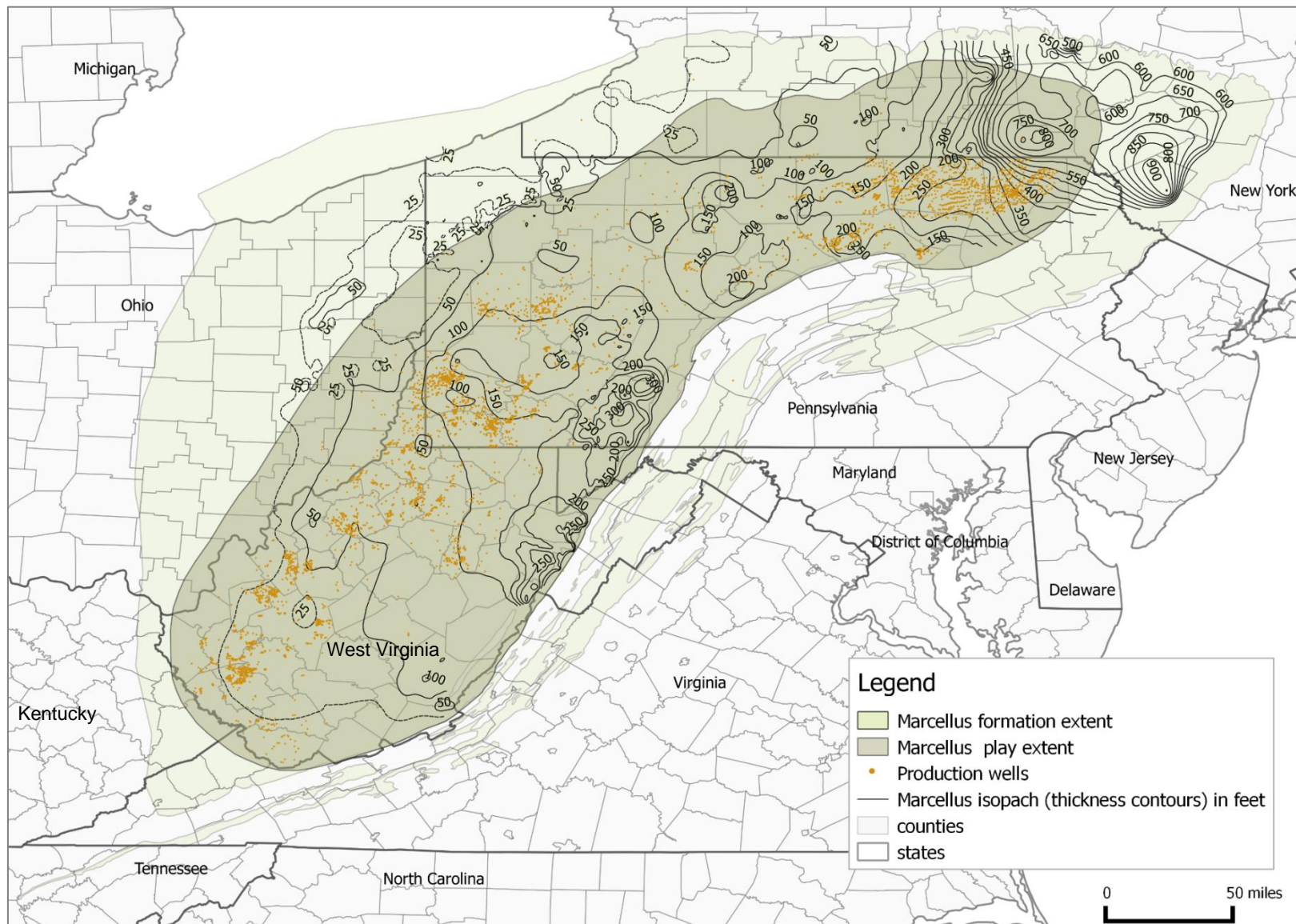


Source: U.S. Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=20612>

based on DrillingInfo Inc., New York State Geological Survey, Ohio State Geological Survey, Pennsylvania Bureau of Topographic & Geologic Survey, West Virginia Geological & Economic Survey, and U.S. Geological Survey

Note: Map includes production wells (7,894) from January 2003 through December 2014.

Thickness map of the Marcellus formation

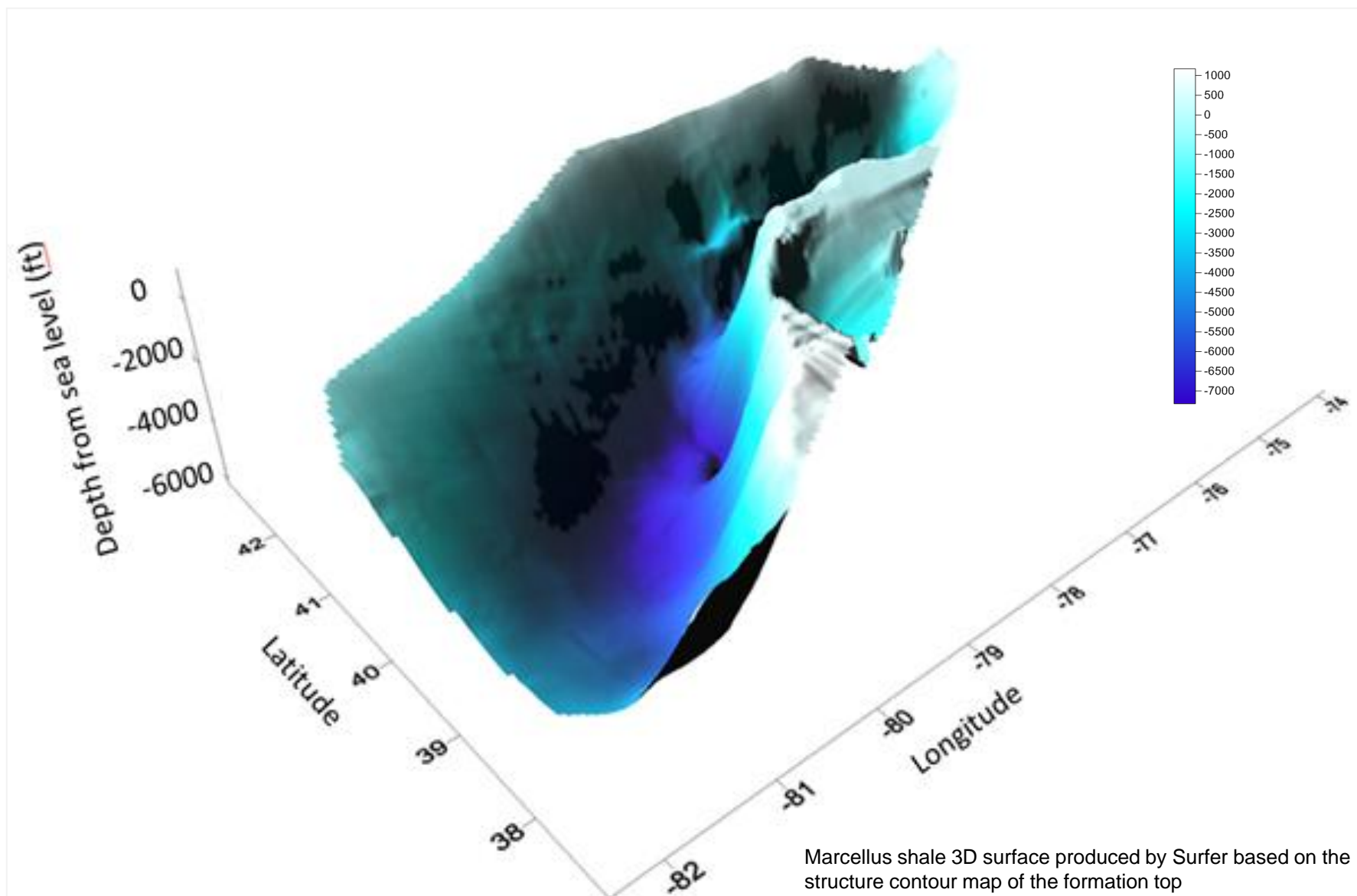


Source: U.S. Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=20612>

based on DrillingInfo Inc., New York State Geological Survey, Ohio State Geological Survey, Pennsylvania Bureau of Topographic & Geologic Survey, West Virginia Geological & Economic Survey, and U.S. Geological Survey

Note: Map includes production wells (7,894) from January 2003 through December 2014.

Marcellus shale 3D surface

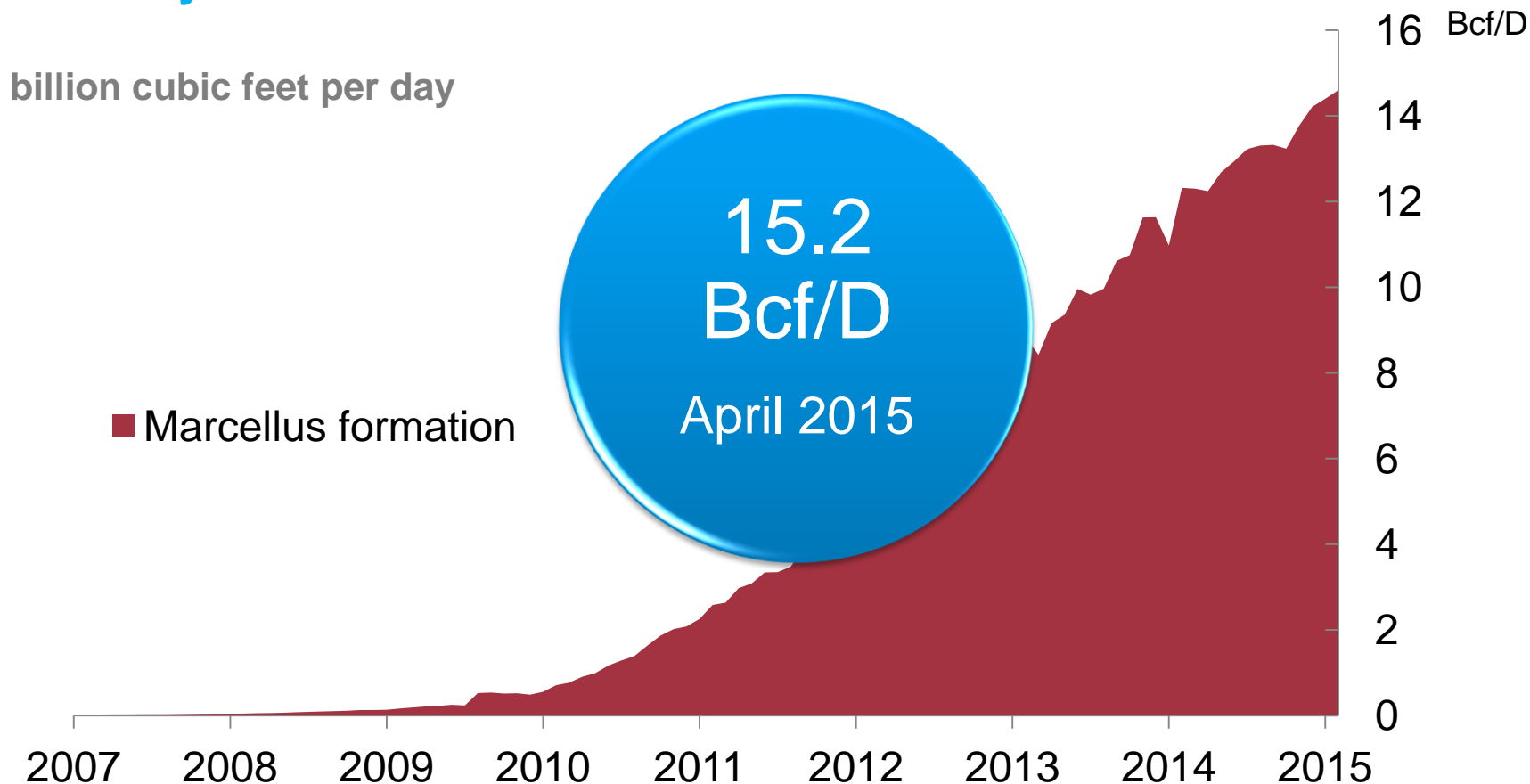


Source: U.S. Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=20612>

based on DrillingInfo Inc., New York State Geological Survey, Ohio State Geological Survey, Pennsylvania Bureau of Topographic & Geologic Survey, West Virginia Geological & Economic Survey, and U.S. Geological Survey

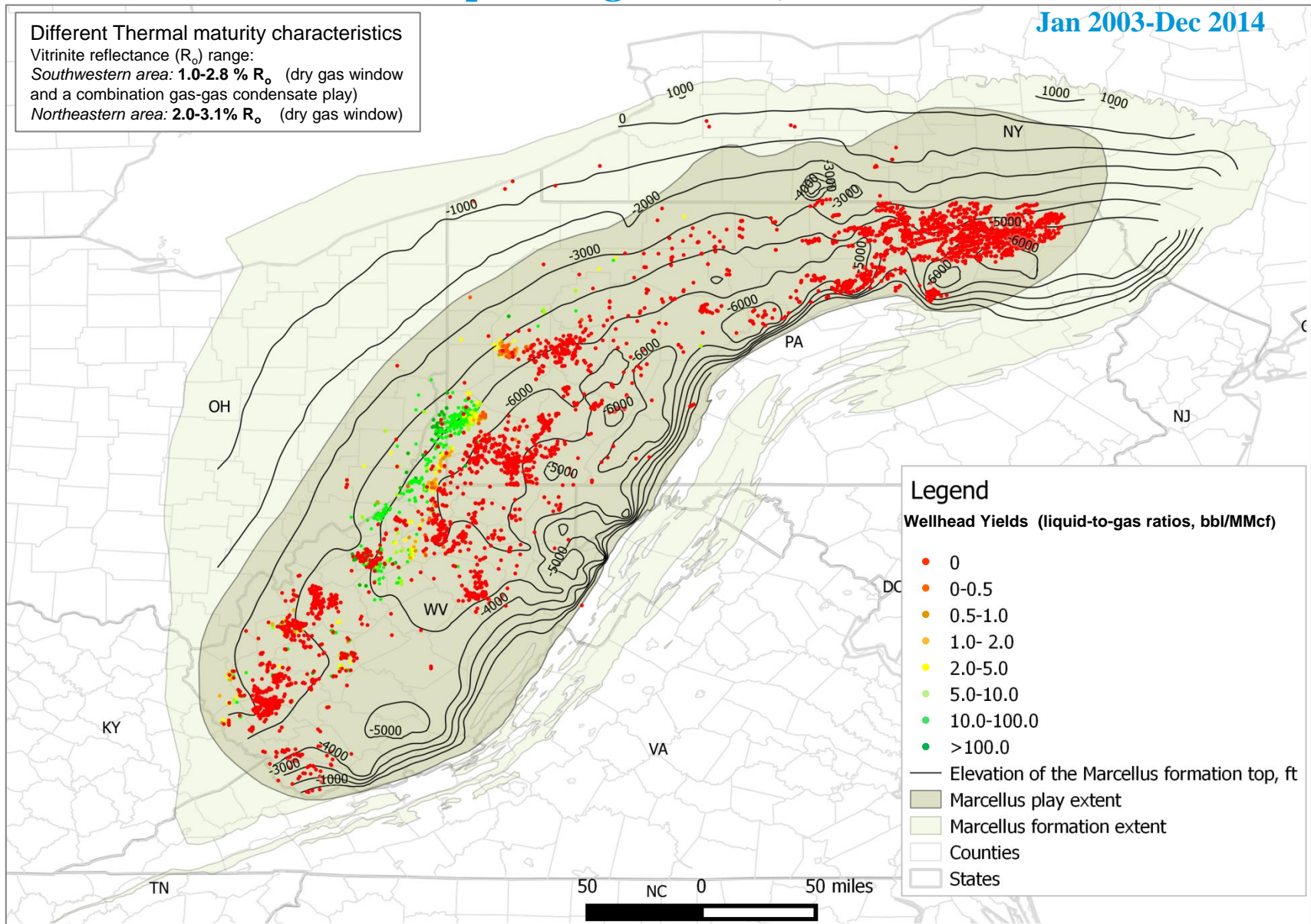
Note: Map includes production wells from January 2003 through December 2014.

Marcellus formation Monthly Natural Gas Production



- > 37% of shale gas production
- > 18% of total dry natural gas production in the US

Initial Wellhead Yields (liquid-to-gas ratios, bbl/MMcf) of Marcellus wells

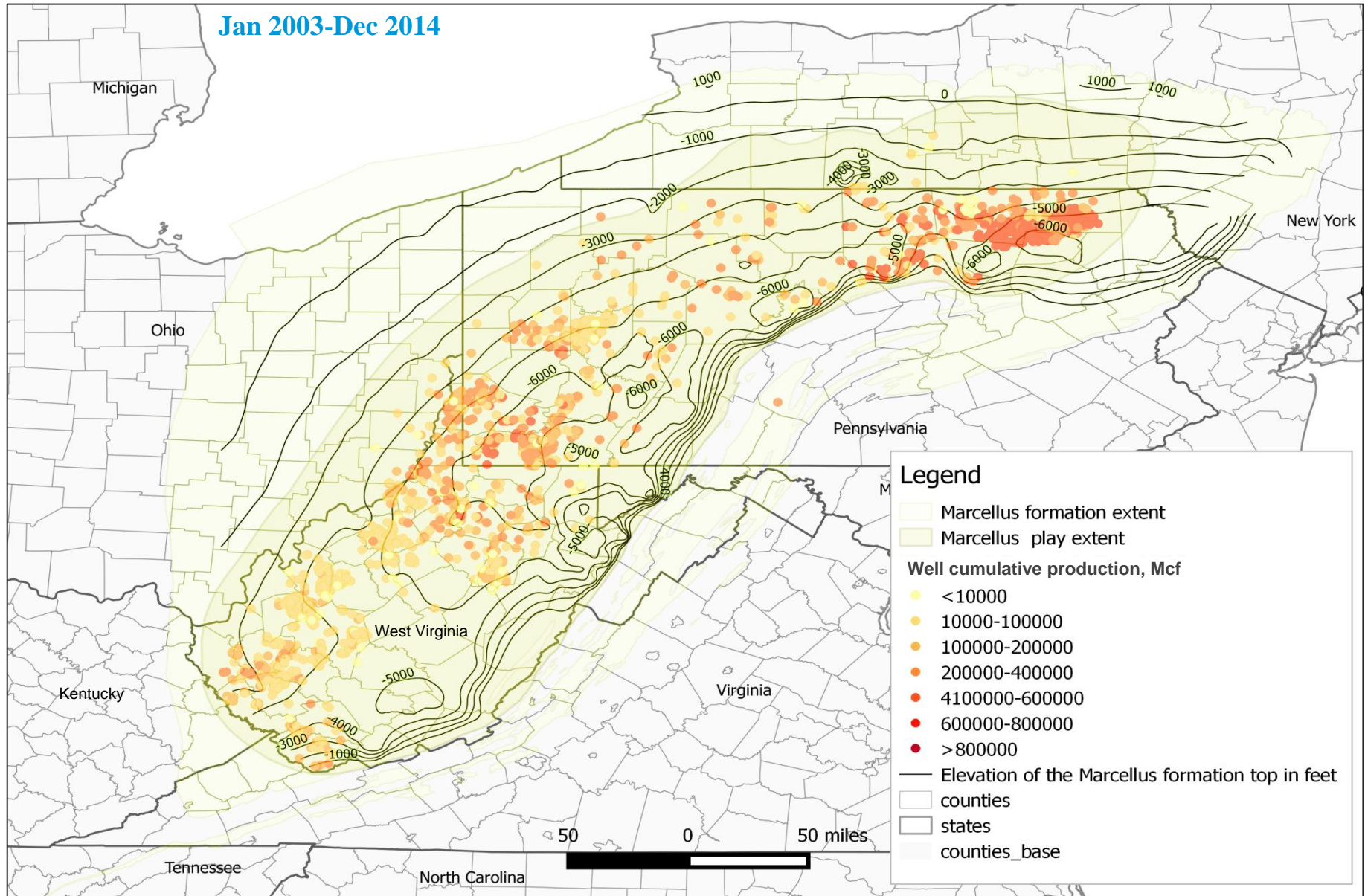


Source: U.S. Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=20612>, based on DrillingInfo Inc.

Note: EIA calculates the initial Yield for each well (7,894) using the second through fourth contiguous months of liquid and/or gas production. Yields are expressed as per barrel per million cubic feet (bbl/MMcf). The first month of production may not represent full production and thus is not included in the initial Yield calculation.

Cumulative Production (Mcf) of Marcellus wells

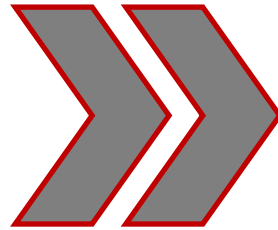
Jan 2003-Dec 2014



Source: U.S. Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=20612>, based on DrillingInfo Inc. and IHS Inc.

Future steps: Multivariate analysis: inputs to resource assessment and production forecast


- Well logs (IHS, States)
 - Depth
 - Thickness
 - Porosity
 - Total organic carbon
- Operator reports (DI, IHS)
 - Shut in Pressure
 - Bottom Hole Temperature
 - Production data
 - Well completion
- Previous research and Core data where available
 - Thermal maturity
 - Kerogen content
 - Permeability



1. Build play model
2. Address uncertainty in reservoir property estimates and resource assessment
3. Identify how formation properties affect Decline curves and recovery factors (geological dependencies)

EIA Online Maps

http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm



Independent Statistics & Analysis
U.S. Energy Information
Administration

Sources & Uses ▾Topics ▾Geography ▾

Tools ▾Learn About Energy ▾News ▾

A-Z ▾
Index

NATURAL GAS

OVERVIEWDATA ▾ANALYSIS & PROJECTIONS ▾GLOSSARY ,FAQS ,

Maps: Exploration, Resources, Reserves, and Production

Summary Maps: Natural gas in the Lower 48 States and North America

Gas production in conventional fields, Lower 48 States	PDF (2.8 MB)	JPG (2.5 MB)
Gas production in offshore fields, Lower 48 States	PDF (0.4 MB)	JPG (1.5 MB)
Shale gas and oil plays, Lower 48 States (4/13/2015)	PDF (1.4 MB)	JPG (0.6 MB)
Shale gas and oil plays, North America (5/9/2011)	PDF (0.4 MB)	JPG (1.2 MB)
Major tight gas plays, Lower 48 States	PDF (1.6 MB)	JPG (2.2 MB)
Coalbed methane fields, Lower 48 States	PDF (1.8 MB)	JPG (2.7 MB)

Oil- and gas-related maps, geospatial data, and geospatial software

- Oil and gas field maps in Portable Document Format
- Oil and gas field data in Shapefile Format
- EIA's oil and gas field Boundary Generation Scripts

Maps in Portable Document Format (.pdf)

The following maps were developed using GIS software and then converted to pdf format. You must therefore have the Adobe Reader® browser plugin installed to view them (free download available at [Adobe Acrobat Reader®](#)). Most of the maps are large format (60 inches X 36 inches, for example) because they were intended for printing on a wide-bed printer. To clearly view them on your monitor you will have to zoom in and then scroll through the map. They will also take more than just a couple of seconds to load owing to their complexity.

Acknowledgment

The authors thank State Agencies for data sharing and expert opinion

Kristin Carter of Pennsylvania Bureau of Topographic & Geologic Survey

Susan Pool and Phil Dinterman of West Virginia Geological & Economic Survey

Ron Riley and Matt Erenpreiss of Ohio State Geological Survey

James Leone of New York State Geological Survey

The authors are grateful to EIA colleagues for peer-reviews and suggestions
**Jim O'Sullivan, Barbara Mariner-Volpe, Jim Kendell, Troy Cook, Jack Perrin,
John Staub, Aloulou Faouzi, and Shirley Neff**

Thank you!



Questions?

AAPG 2015 Annual Convention & Exhibition
May 31-June 3, 2015, Denver, Colorado



References

Boyce, M. and Carr, T., 2010, Stratigraphy and petrophysics of the Middle Devonian black shale interval in West Virginia and southwest Pennsylvania, Conference proceedings, AAPG annual convention & exhibition, Denver, CO, 2010. Available at: http://www.searchanddiscovery.com/abstracts/pdf/2010/annual/abstracts/ndx_boyce.pdf.

Carter, K.M., Harper, J.A., Schmid, K.W., Kostelnik, J., 2011, Unconventional natural gas resources in Pennsylvania: The backstory of the modern Marcellus Shale play Environmental Geosciences, December 2011, v. 18, p. 217-257.

Coleman, J. L., Milici, R.C., Cook, T.A., Charpentier, R.R., Kirshbaum, M.A., Klett, T.R., Pollastro, R.M., and Schenk, C.J., 2011, Assessment of undiscovered oil and gas resources of the Devonian Marcellus shale of the Appalachian basin province, 2011: U.S. Geological Survey Fact Sheet FS-2011-3092, 2 p. Available at: <http://pubs.usgs.gov/fs/2011/3092/>.

de Witt Jr., W., Roen, J. B., and Wallace, L. G., 1993, Stratigraphy of Devonian black shales and associated rocks in the Appalachian Basin, in Roen, J. B. and Kepferle, R. C., eds., 1993, Petroleum geology of the Devonian and Mississippian black shale of eastern North America: U.S. Geological Survey Bulletin, v. 1909, p. M1-M16.

East, J.A., Swezey, C.S., Repetski, J.E., and Hayba, D.O., 2012, Thermal maturity map of Devonian shale in the Illinois, Michigan, and Appalachian basins of North America: U.S. Geological Survey Scientific Investigations Map 3214, 1 sheet. Available at: <http://pubs.usgs.gov/sim/3214/>

Harper, J. A. and Laughrey, C. D., 1987, Geology of the oil and gas fields of southwestern Pennsylvania: Commonwealth of Pennsylvania Mineral Resource Report 87, p. 91-97.

Ikonnikova S., Browning J., Gulen G., and Tinker, S., 2015, Factors influencing shale gas production forecasting: Empirical studies of Barnett, Fayetteville, Haynesville, and Marcellus Shale plays. Economics of Energy & Environmental Policy, Volume 4, Issue 1, 19-35.

Repetski, J.E., Ryder, R.T., Weary, D.J., Harris, A.G., and Trippi, M.H., 2008, Thermal maturity patterns (CAI and %Ro) in Upper Ordovician and Devonian rocks of the Appalachian basin: A major revision of USGS Map I-917-E using new subsurface collections: U.S. Geological Survey Scientific Investigations Map 3006, one CD-ROM. Available at: <http://pubs.usgs.gov/sim/3006/>.

Roen, J. B. and Walker, B. J., eds., 1996, The atlas of major Appalachian gas plays, West Virginia Geological and Economic Survey Publication 25: Morgantown, WV, 1996, U.S. Department of Energy, Morgantown Energy Technology Center.