Stable Carbon Isotope Reversal Does Not Correlate to Production in the Marcellus Shale*

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Abstract

Do trends in stable carbon isotopes correlate to production in shale gas plays? It has long been noted that the stable carbon isotopes of hydrocarbons such as methane, ethane, and propane tend to become isotopically heavier with higher thermal maturity. Recently, workers have encountered a reversal in this trend in several horizontal plays such as the Barnett Shale of west Texas and the Haynesville Shale in Louisiana. In these areas, the stable carbon isotopes of ethane and propane become isotopically lighter with depth, a reversal of the normal trend. While this trend could be interpreted as mixing of gases with different origin and maturity, the low permeability of these formations makes this unlikely. Although the mechanism of this reversal presently remains unclear, there is an association between the presence of this isotopic anomaly and increased production in some horizontal plays.

Using isotopes to predict areas of higher production was evaluated in the Marcellus Shale in western Pennsylvania. The results of this work indicate that stable carbon isotopes go through the same reversal process as in other plays, but the trends are the same in both areas of good and poor production. Rather than acting as a signal for higher production volumes, the reversal in isotopic trend is probably indicative of maturity and the stratigraphic horizon of this reversal is likely due to the occurrence of better seals within shale members seen throughout the Hamilton Formation. Therefore, better production in the Marcellus Shale seems to be more closely related to traditional matrix parameters like porosity and permeability than trends in stable carbon isotopes.

Selected References

Harper, J.A., 1999, Devnonian, *in* C.H. Schultz, (ed.), the Geology of Pennsylvania: Chapter 7, p. 129-137.

Milici, R.C., R.T. Ryder, and J.E. Repetski, 2006, Exploration for hydrocarbons in the southern Appalachian Basin; an overview: GSA Abstracts with Programs, v. 38/3, p. 10-11.

Tilley, B., S. McLellan, S. Hiebert, B. Quartero, R. Veilleux, and K. Muehlenbachs, 2011, Gas isotope reversals in fractured gas reservoirs of the Western Canadian Foothills; mature shale gases in disguise: AAPG Bulletin, v. 95/8, p. 13991422.

Zumberge, J., K. Ferworn, and S. Brown, 2012, Isotopic reversal ("rollover") in shale gases produced from the Mississippian Barnett and Fayetteville formations: Marine and Petroleum Geology, v. 31/1/, p. 43-52.

Website

Census Finder Directory: Web accessed 21 June 2012.
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June 28, 2012

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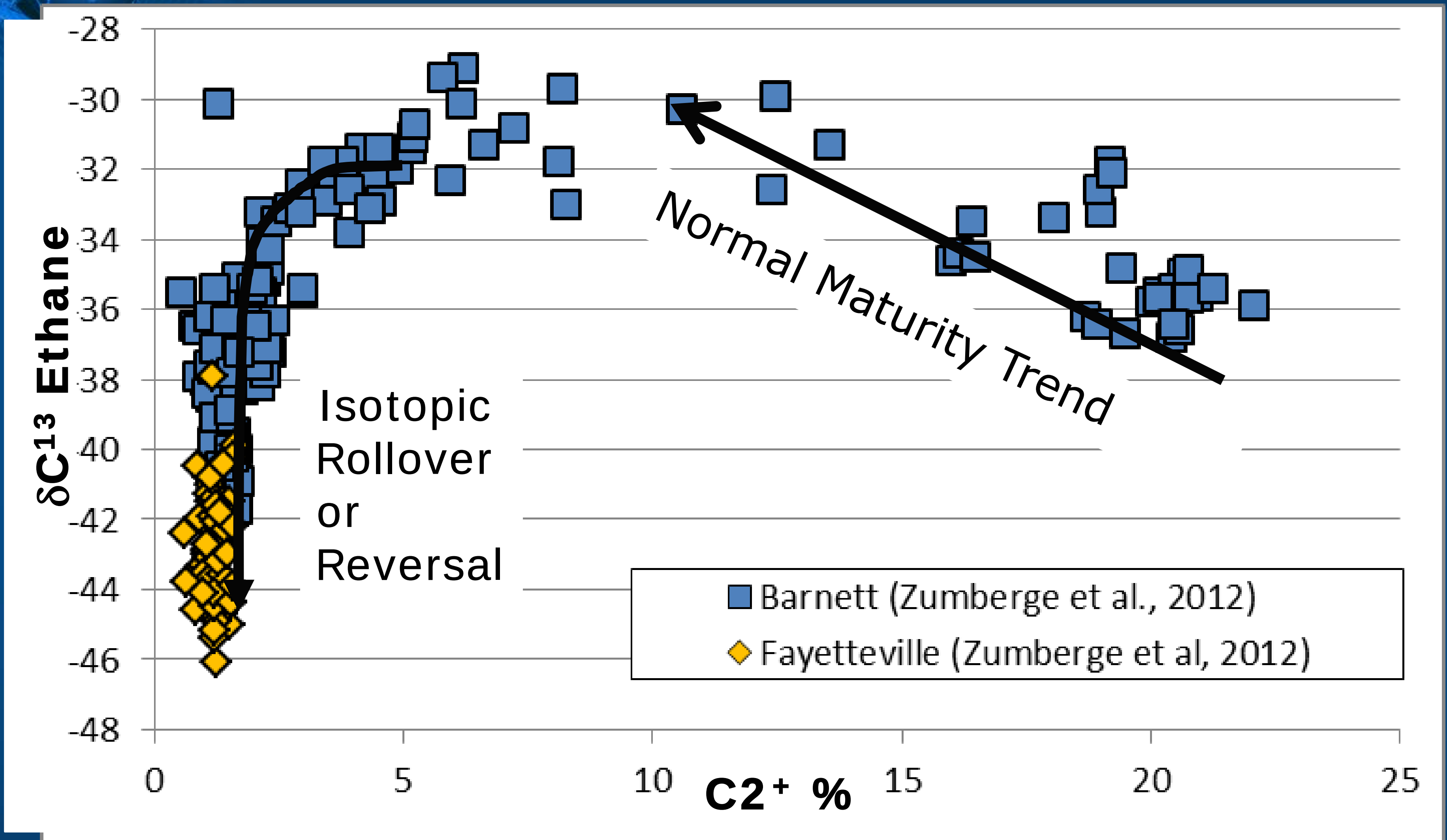
Anadarko

Outline

- **Isotopic Rollover**
  - Barnett/Fayetteville
  - Marcellus

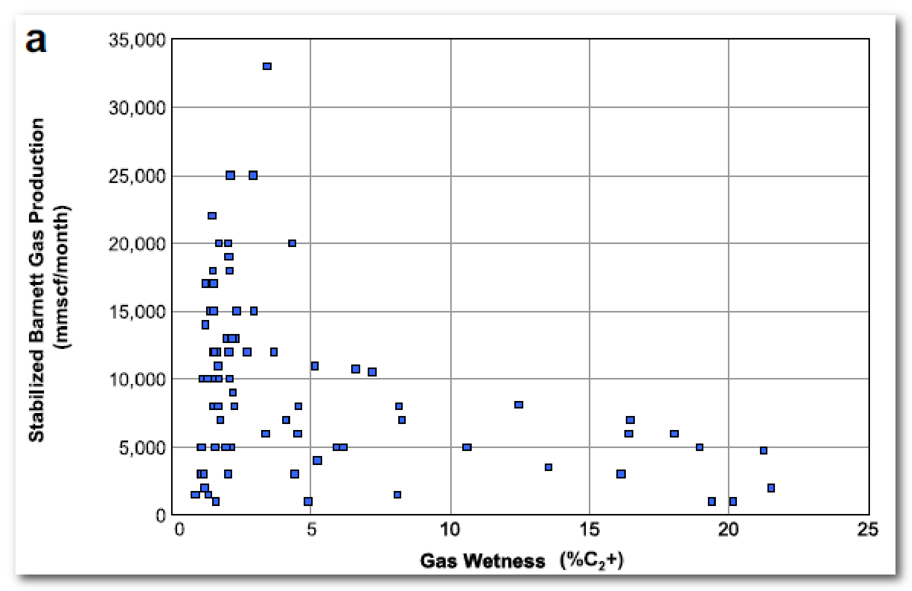
- **Integrating Isotopic Rollover into Petroleum Systems Analysis**

Isotopic Rollover Examples

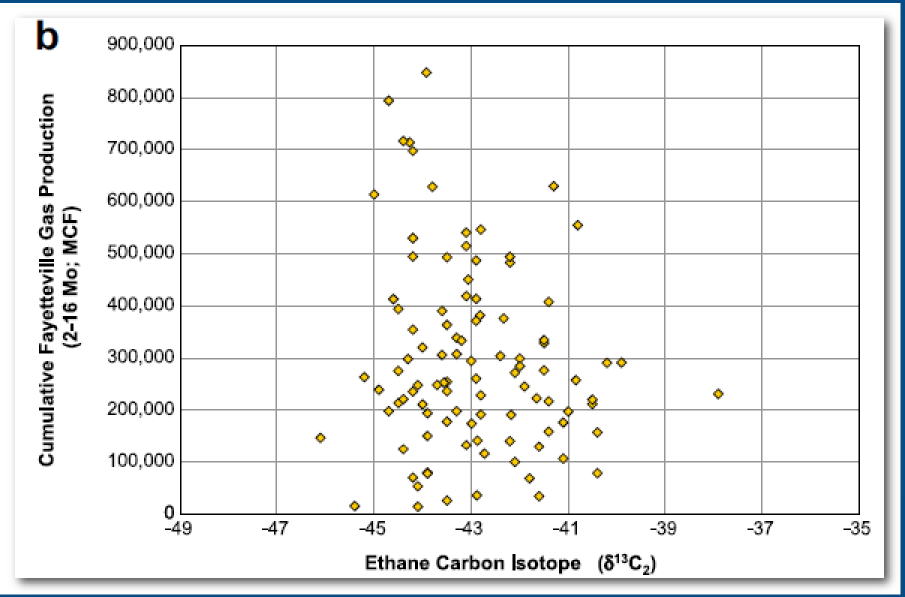


Correlation of Rollover to Production

Barnett



Fayetteville

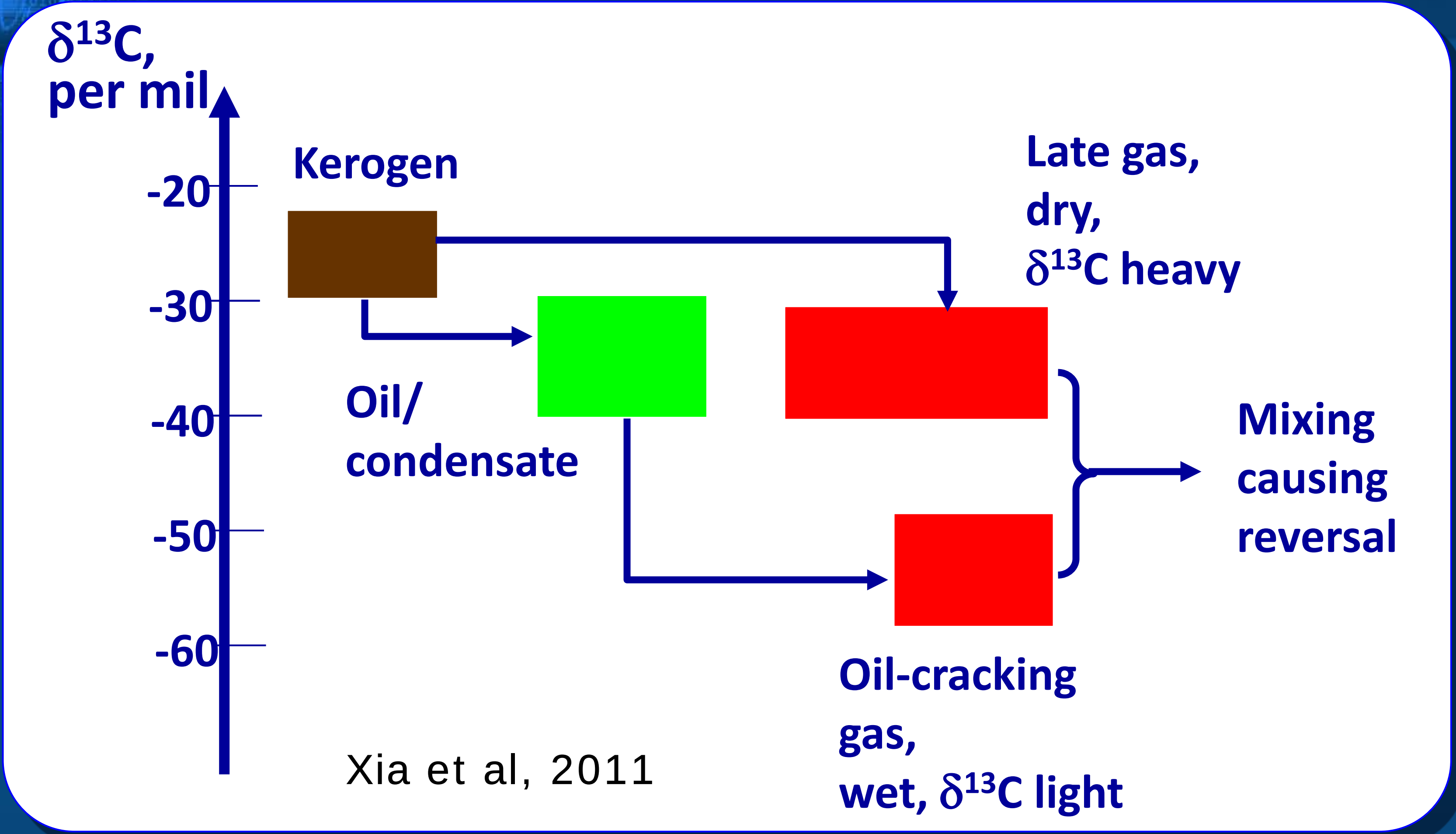


Better production associated with rollover

Rollover wells that under perform are associated with variations in completion and lateral length

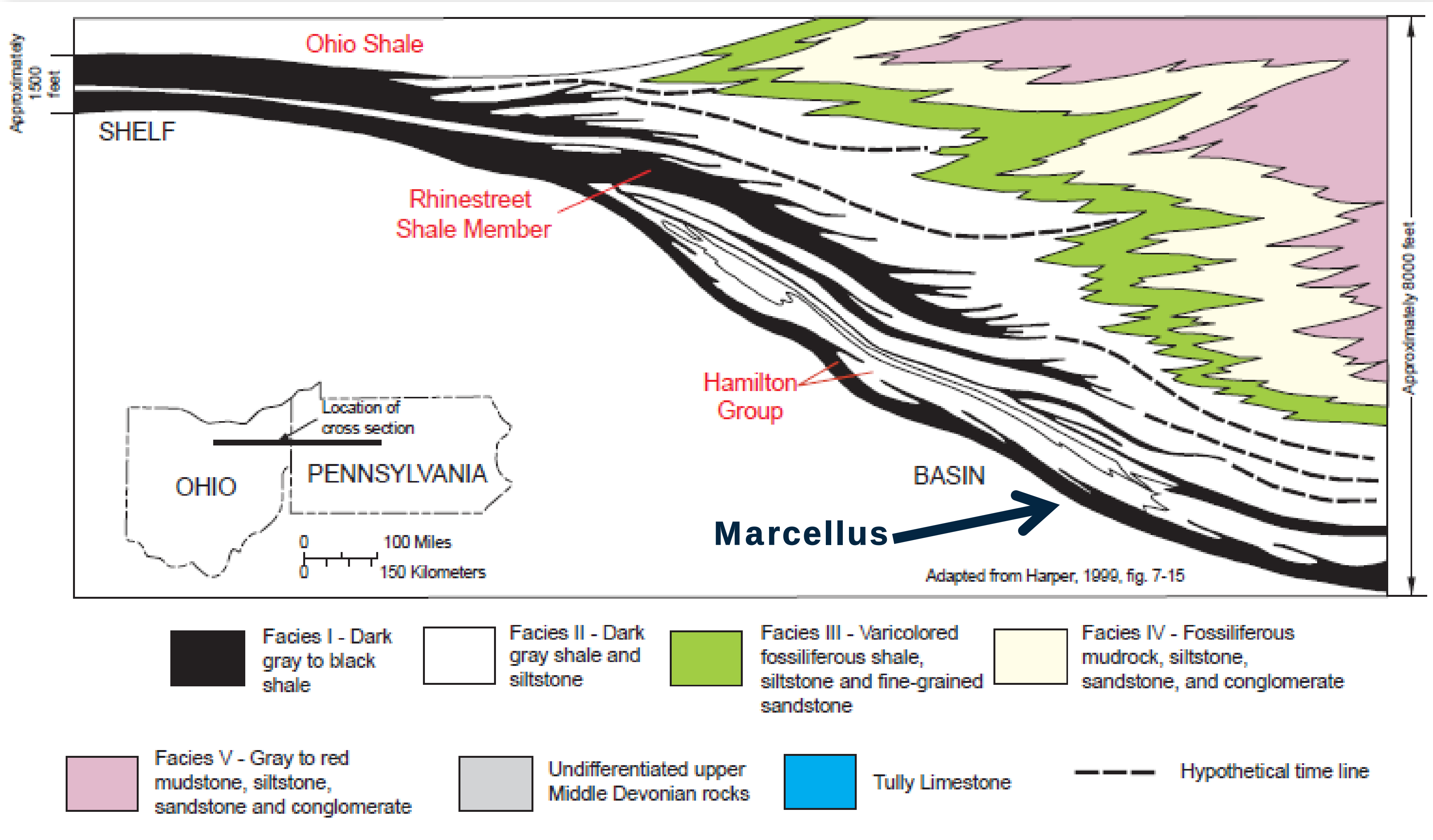
Zumberge et al., 2012

Mechanism for Rollover



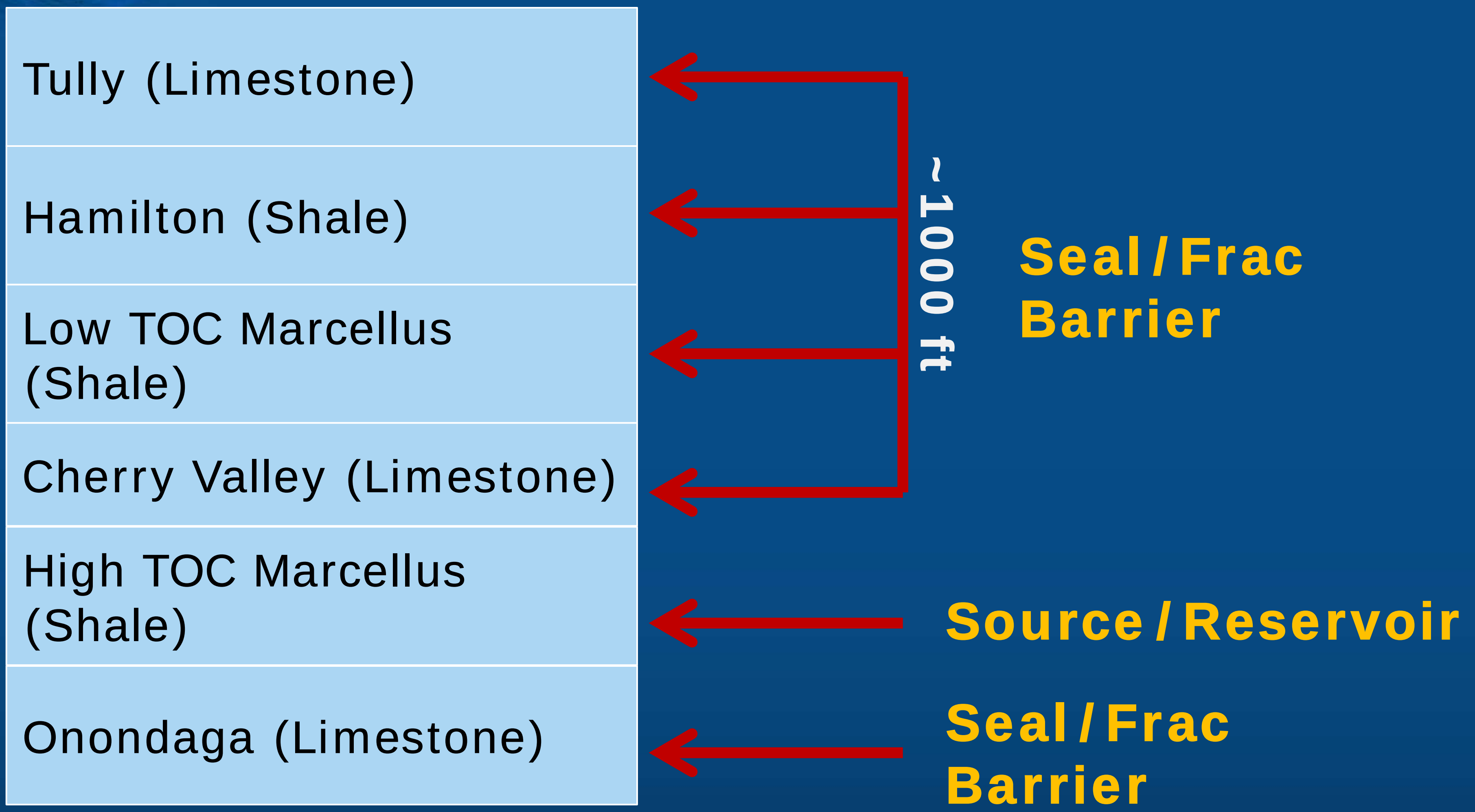
- **Rollover occurs at high maturity with a good seal**
- **Agrees with observations from Tilley et al., 2011**

Marcellus Deposition

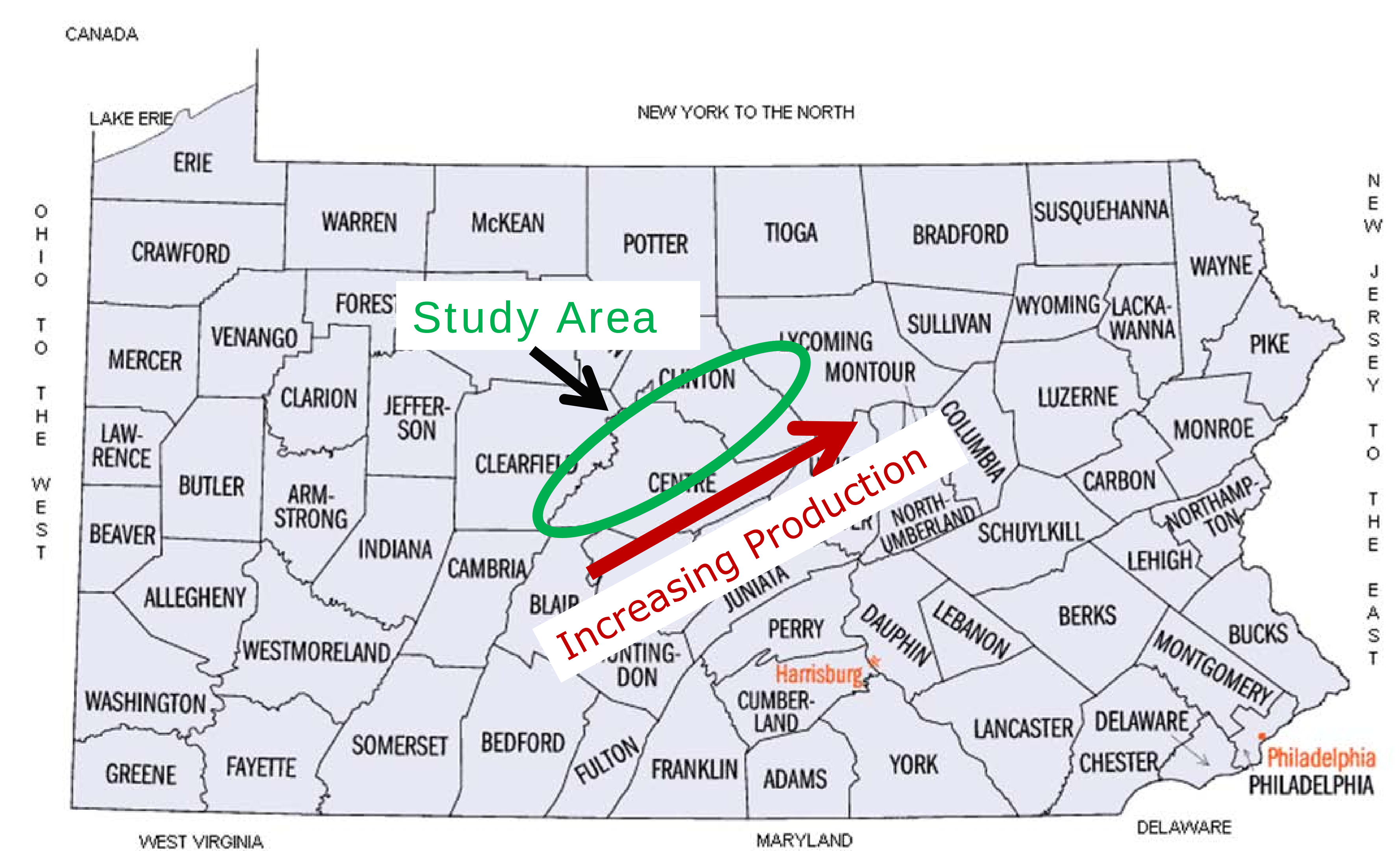


Milici et al., 2006

Marcellus Stratigraphy

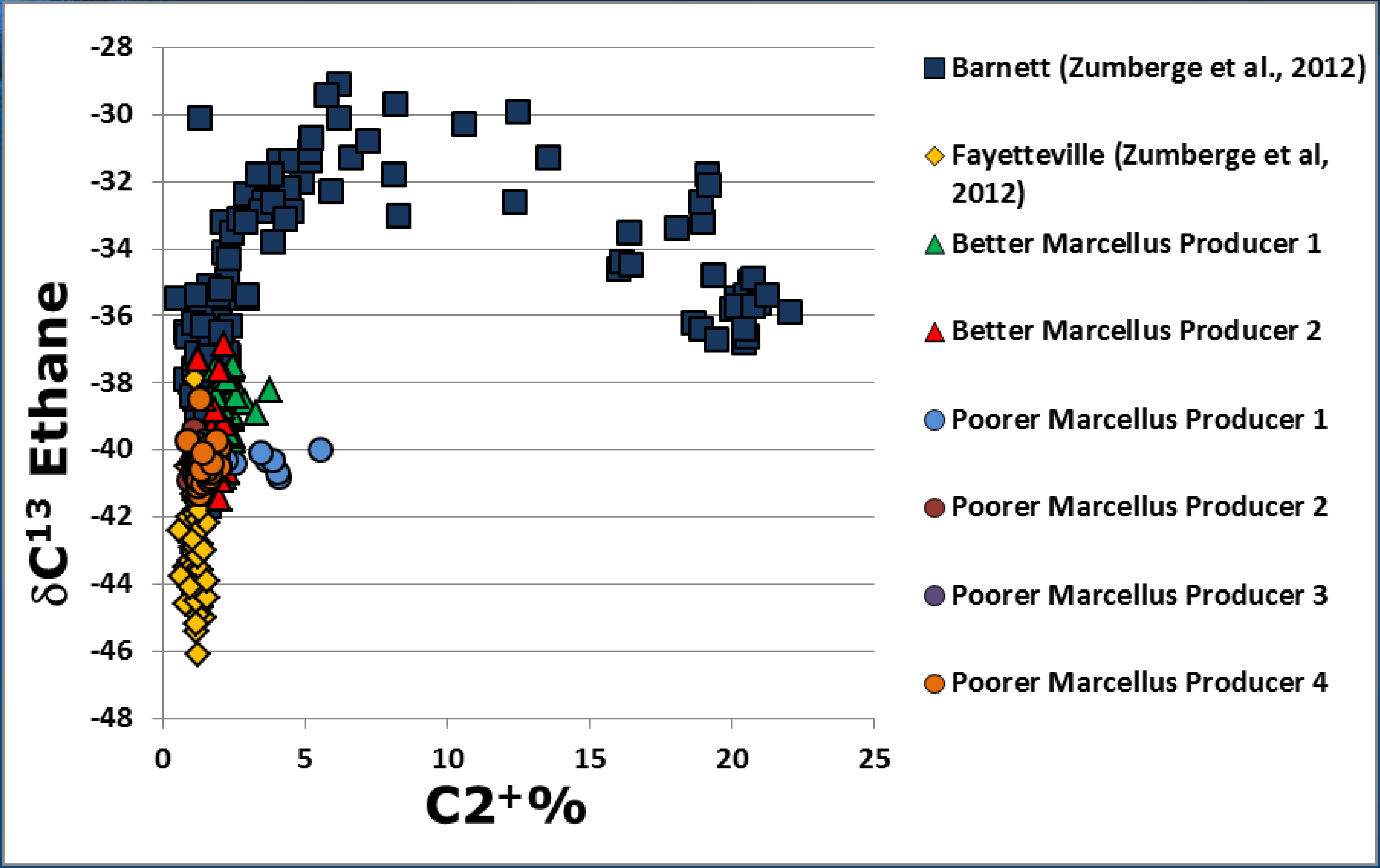


Study Area



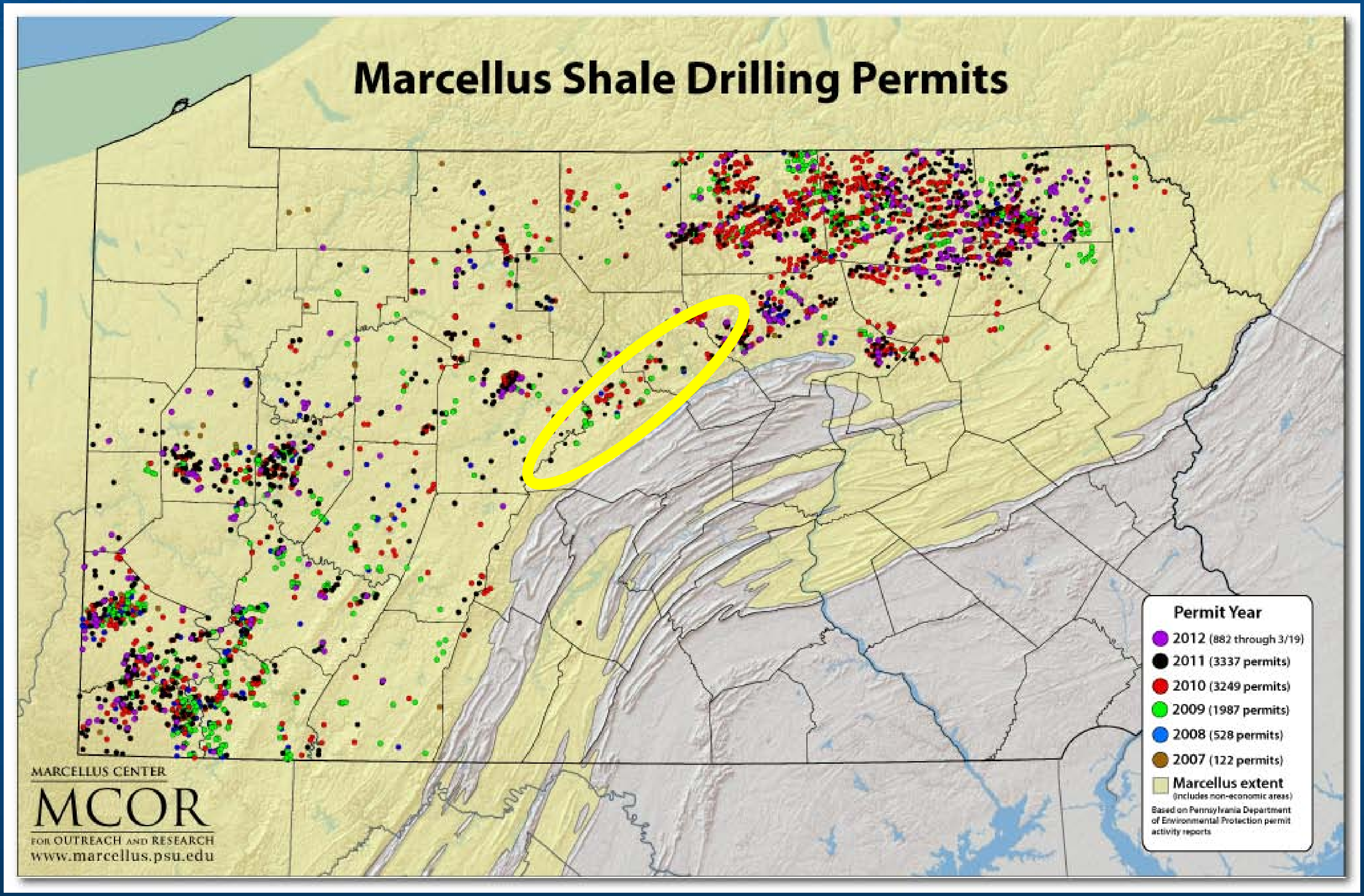
http://www.censusfinder.com/_derived/mappa.htm_txt_mappasmall.gif

Rollover in the Marcellus

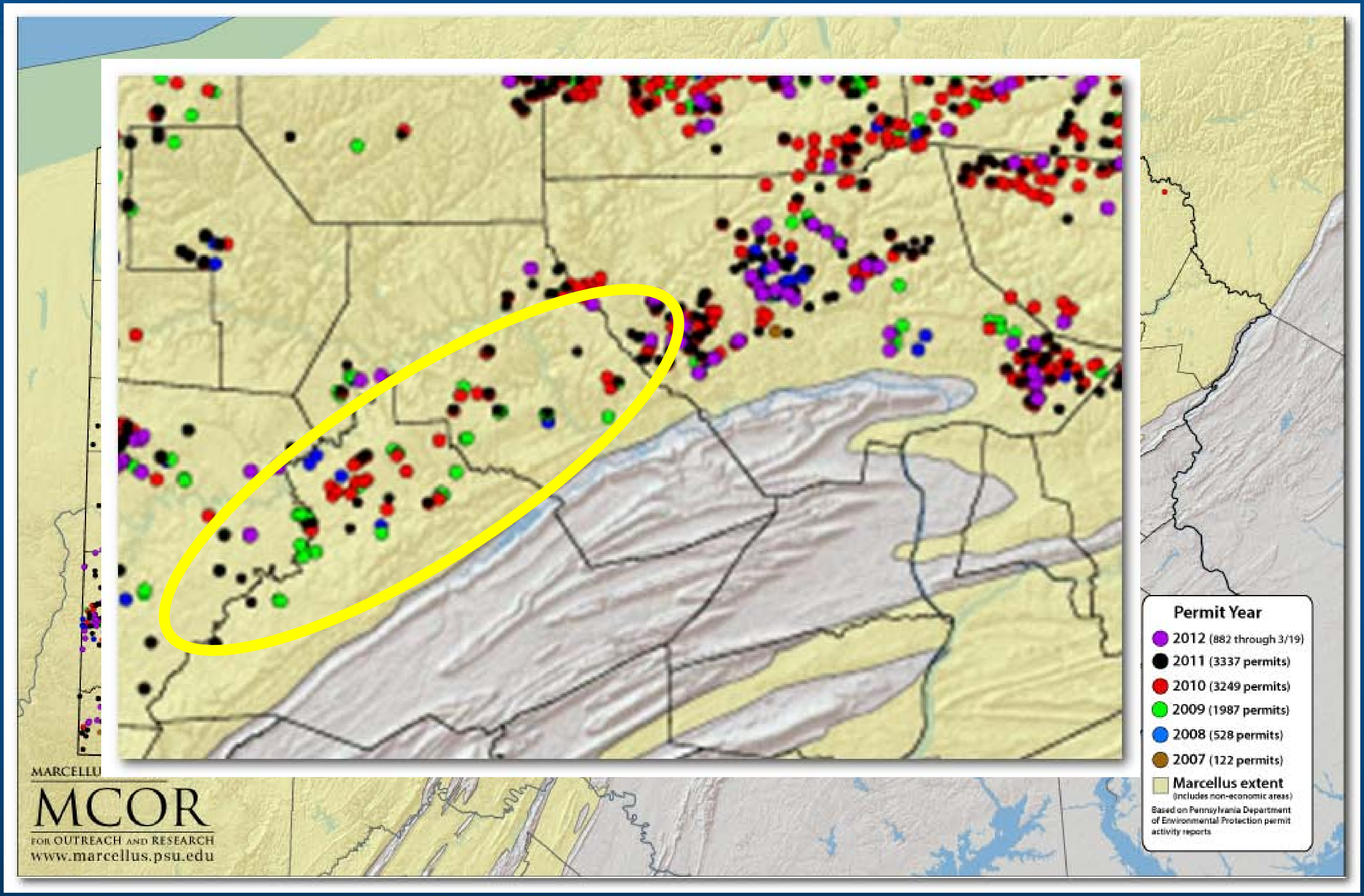


- **Isotopic rollover does not discriminate between poorer and better producers**
- **Similar lateral lengths and completions**

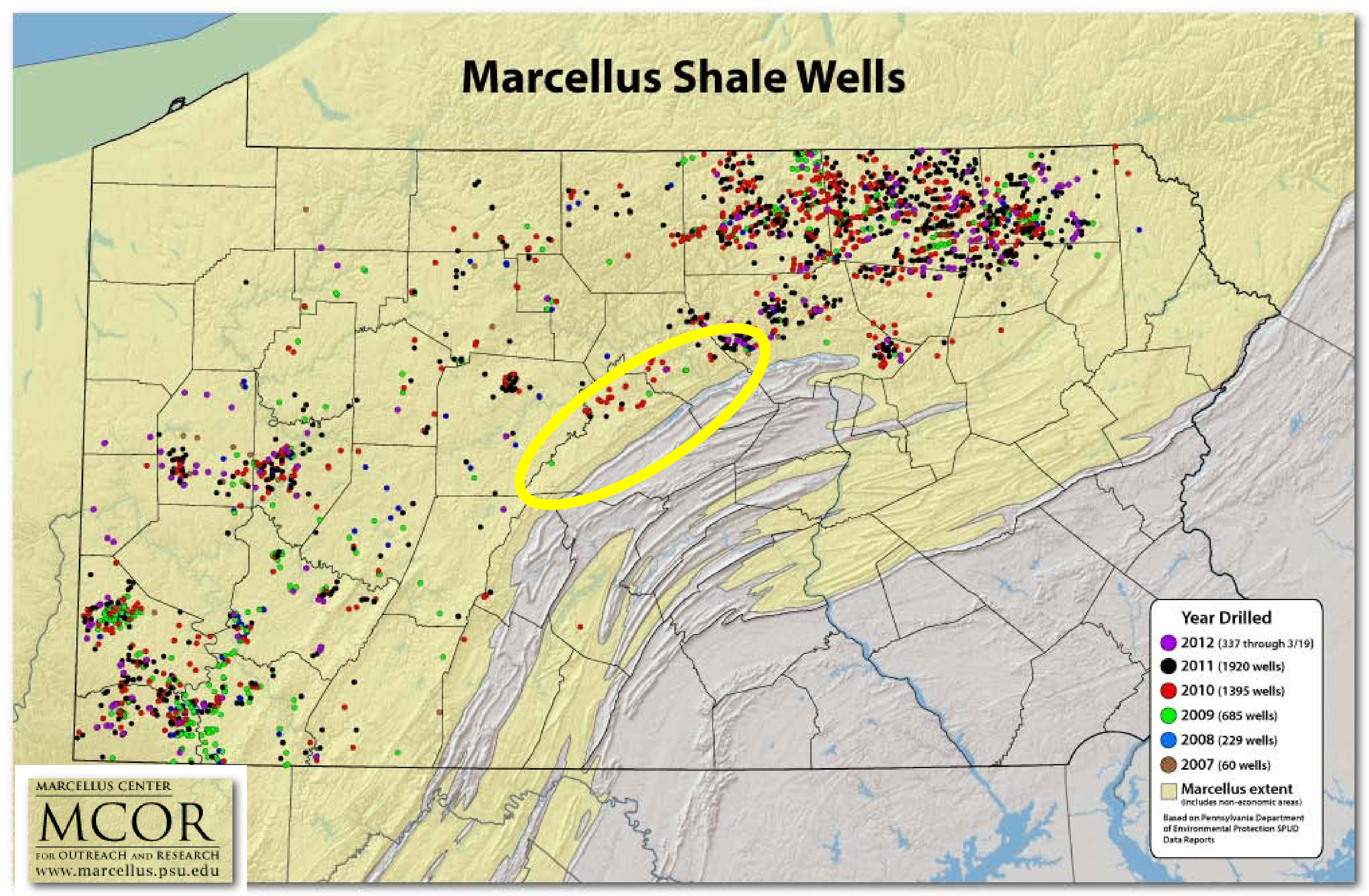
Permitting Activity



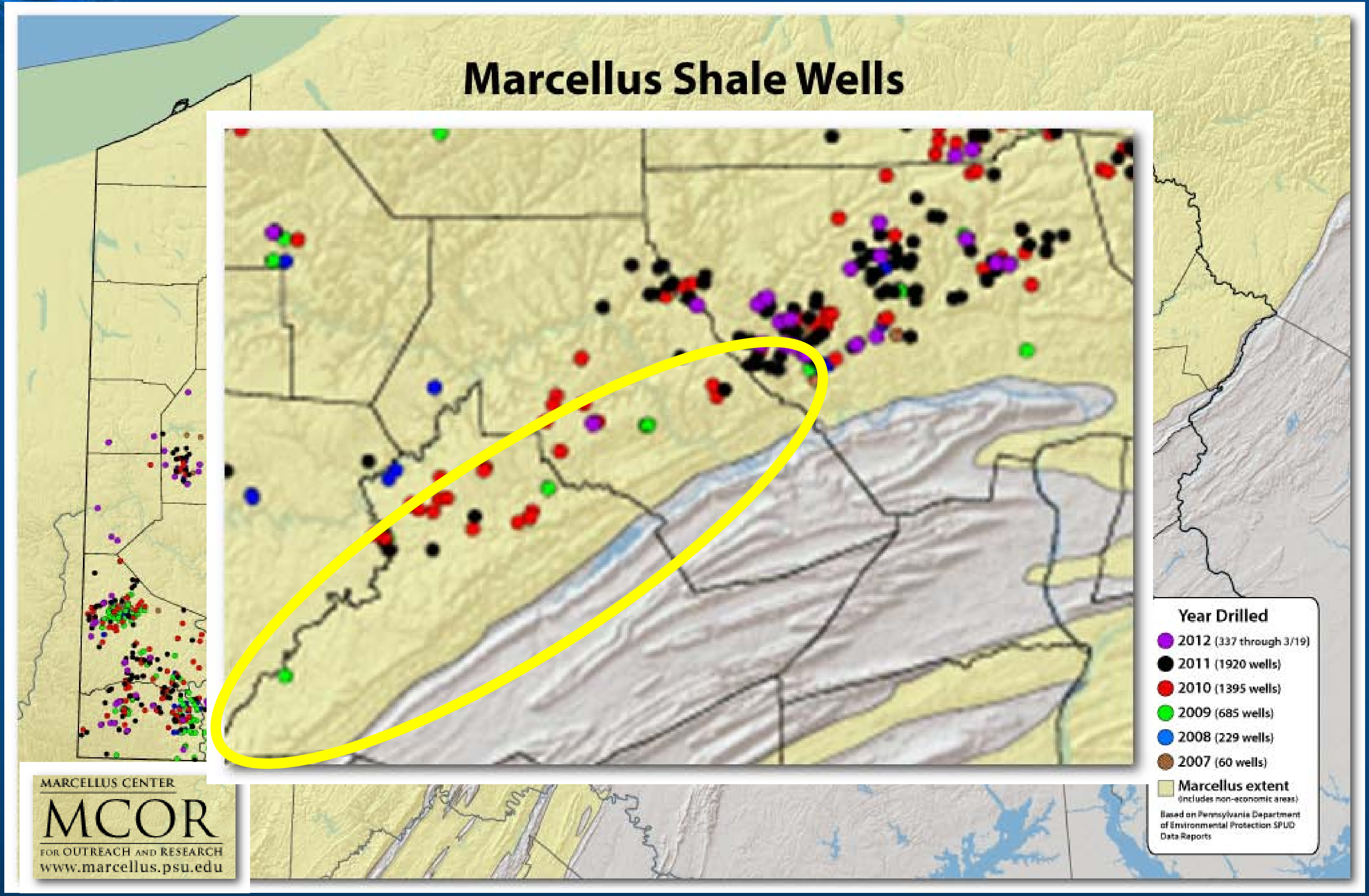
Permitting Activity



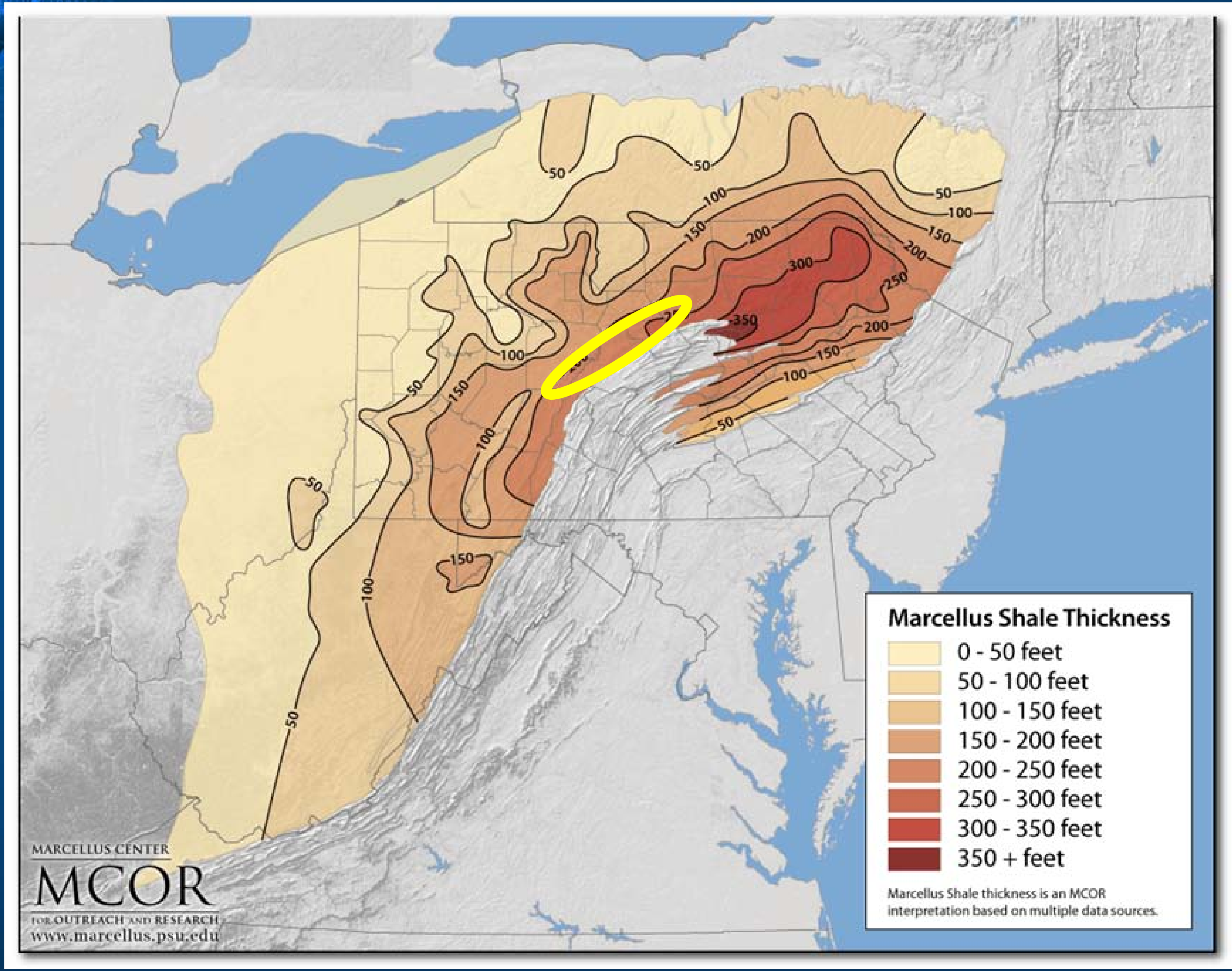
Drilling Activity



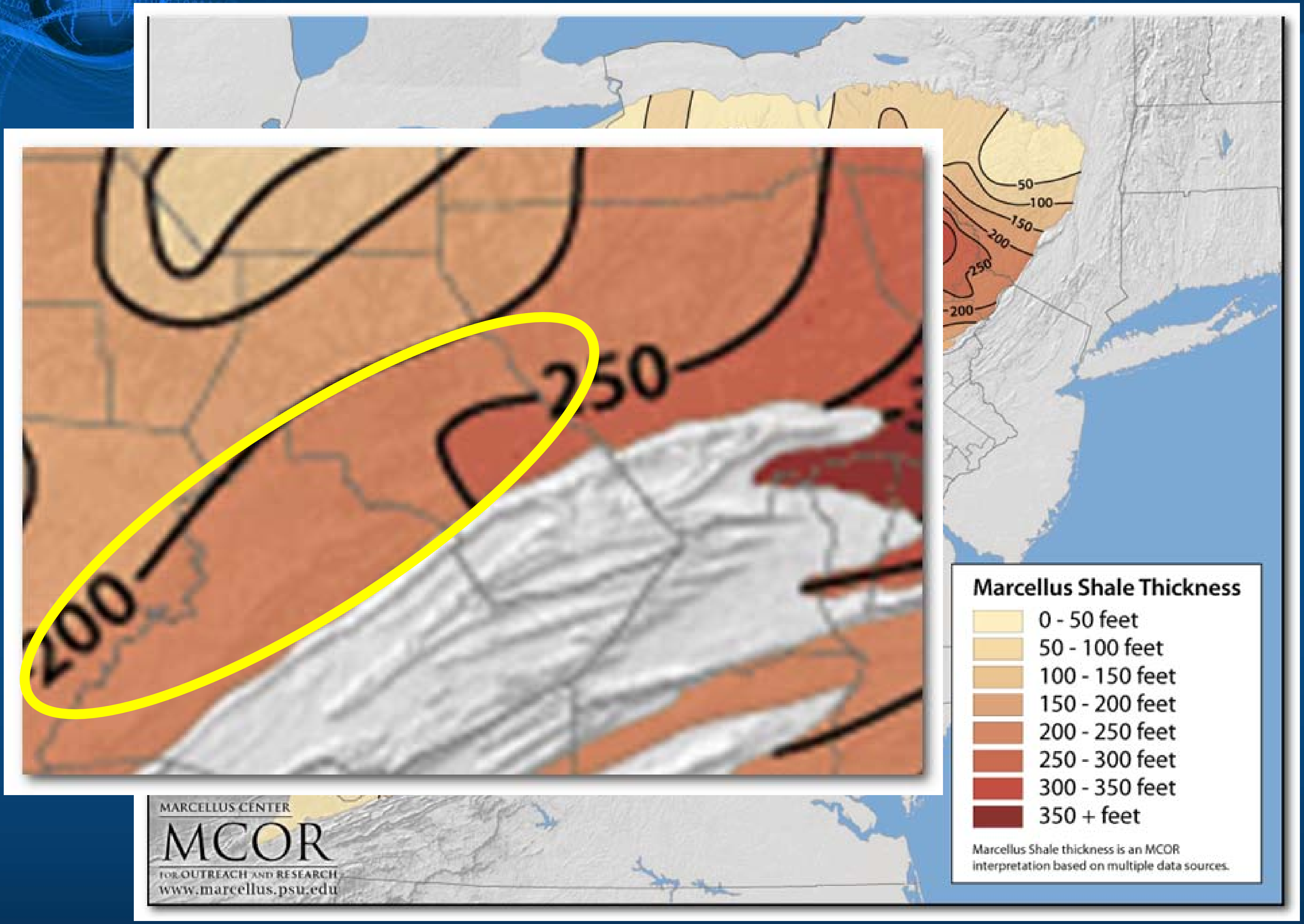
Drilling Activity



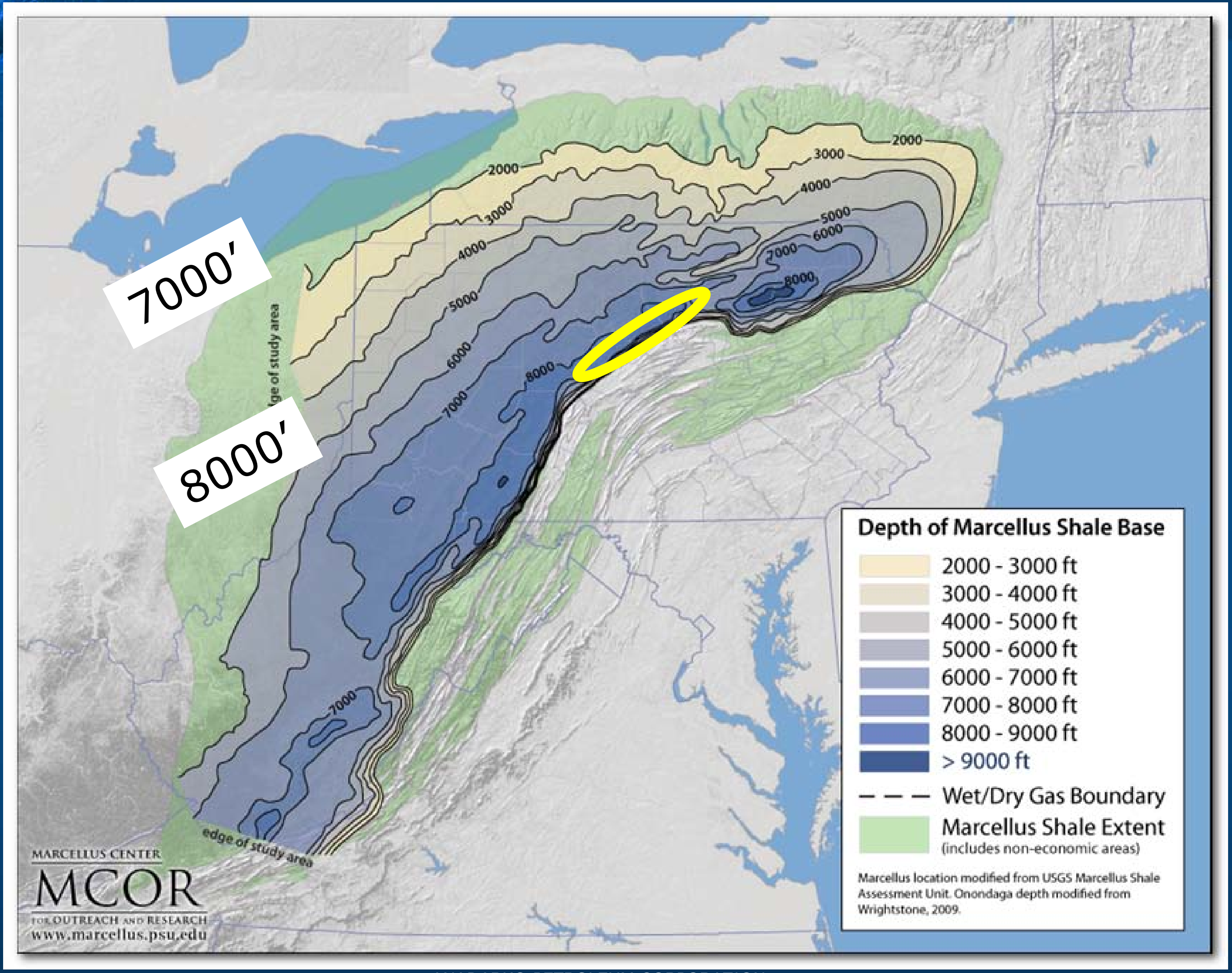
Marcellus Shale Thickness



Marcellus Shale Thickness



Present Depth of Burial



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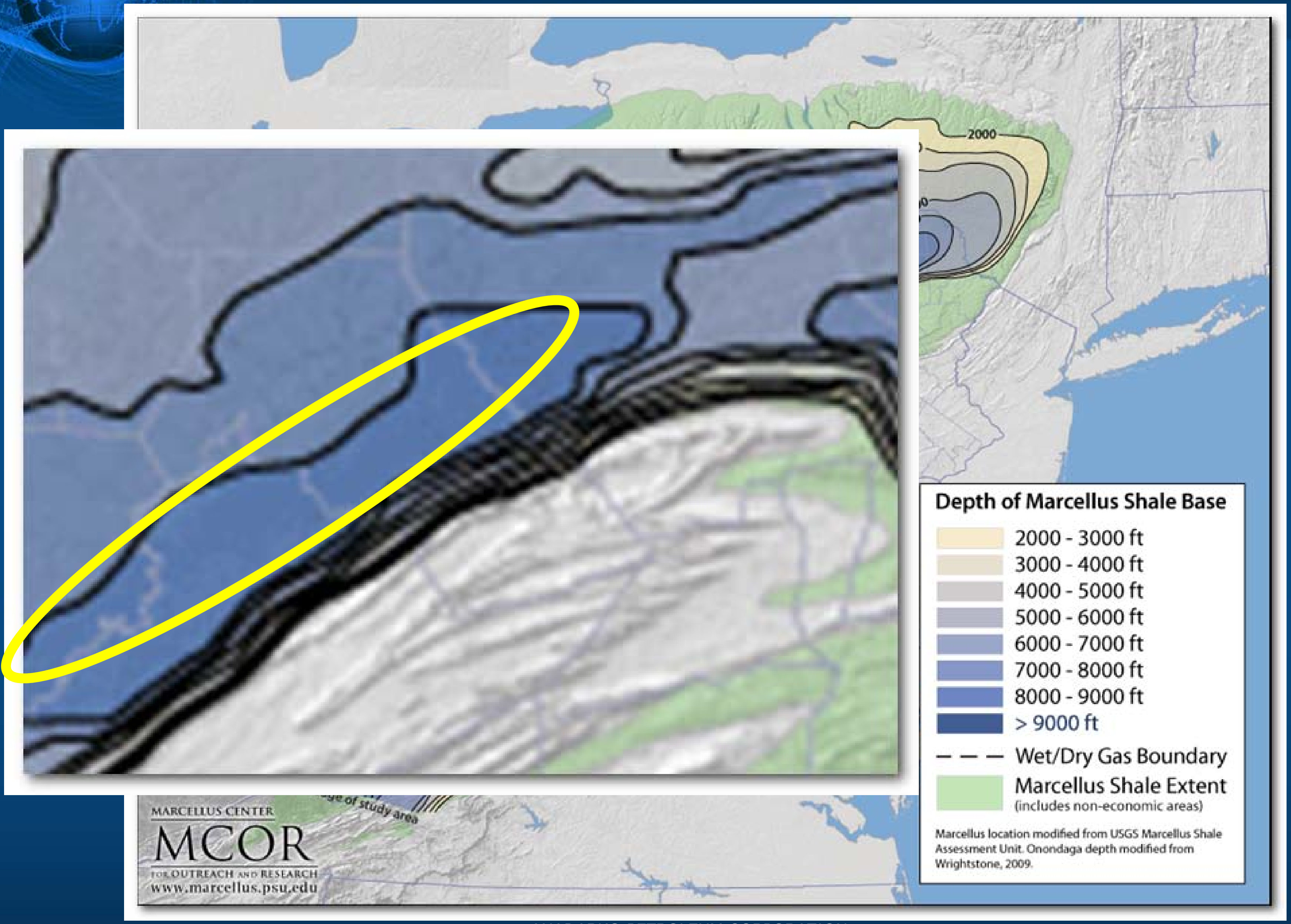
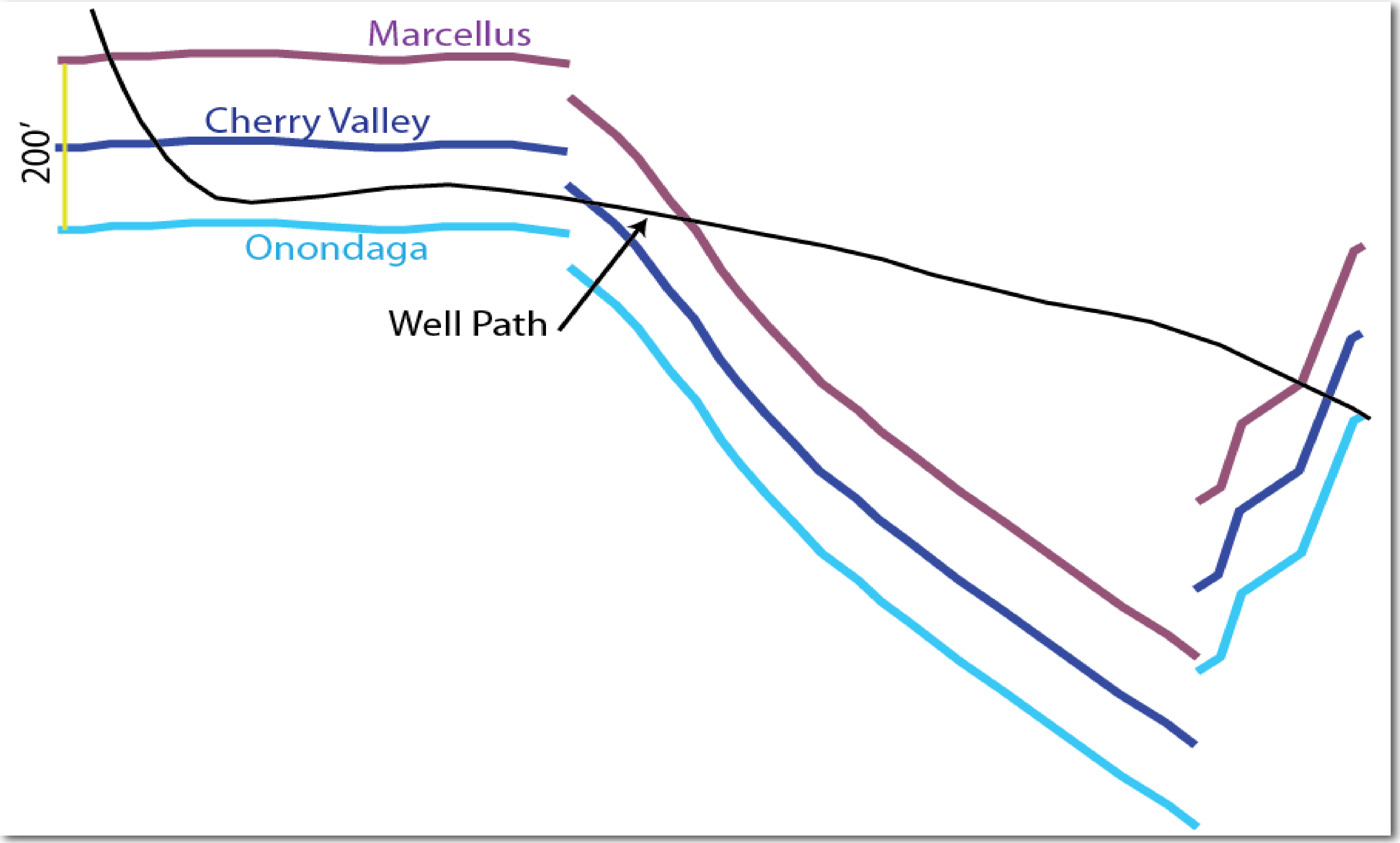
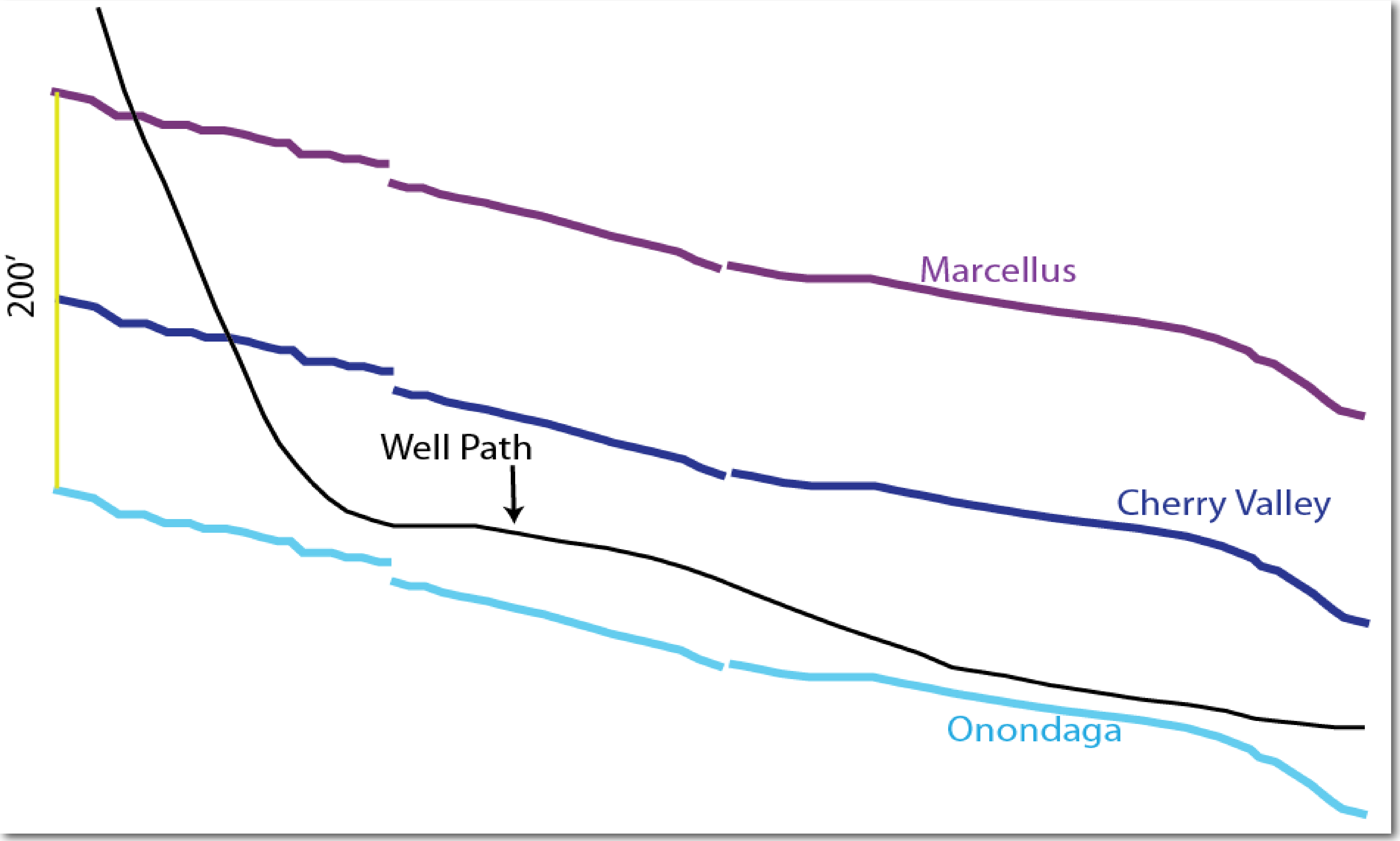


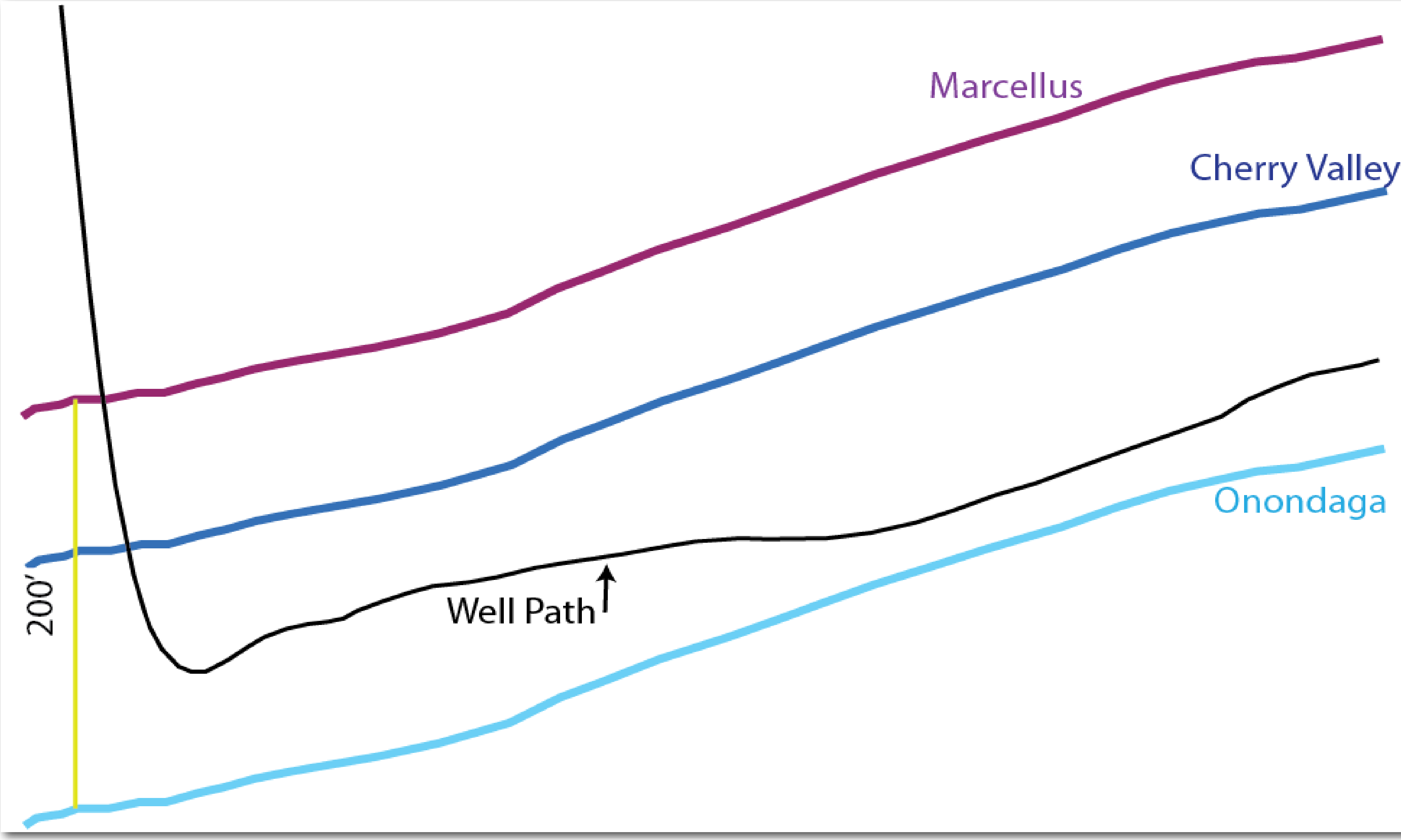
Example of Structure from Poorer Producer



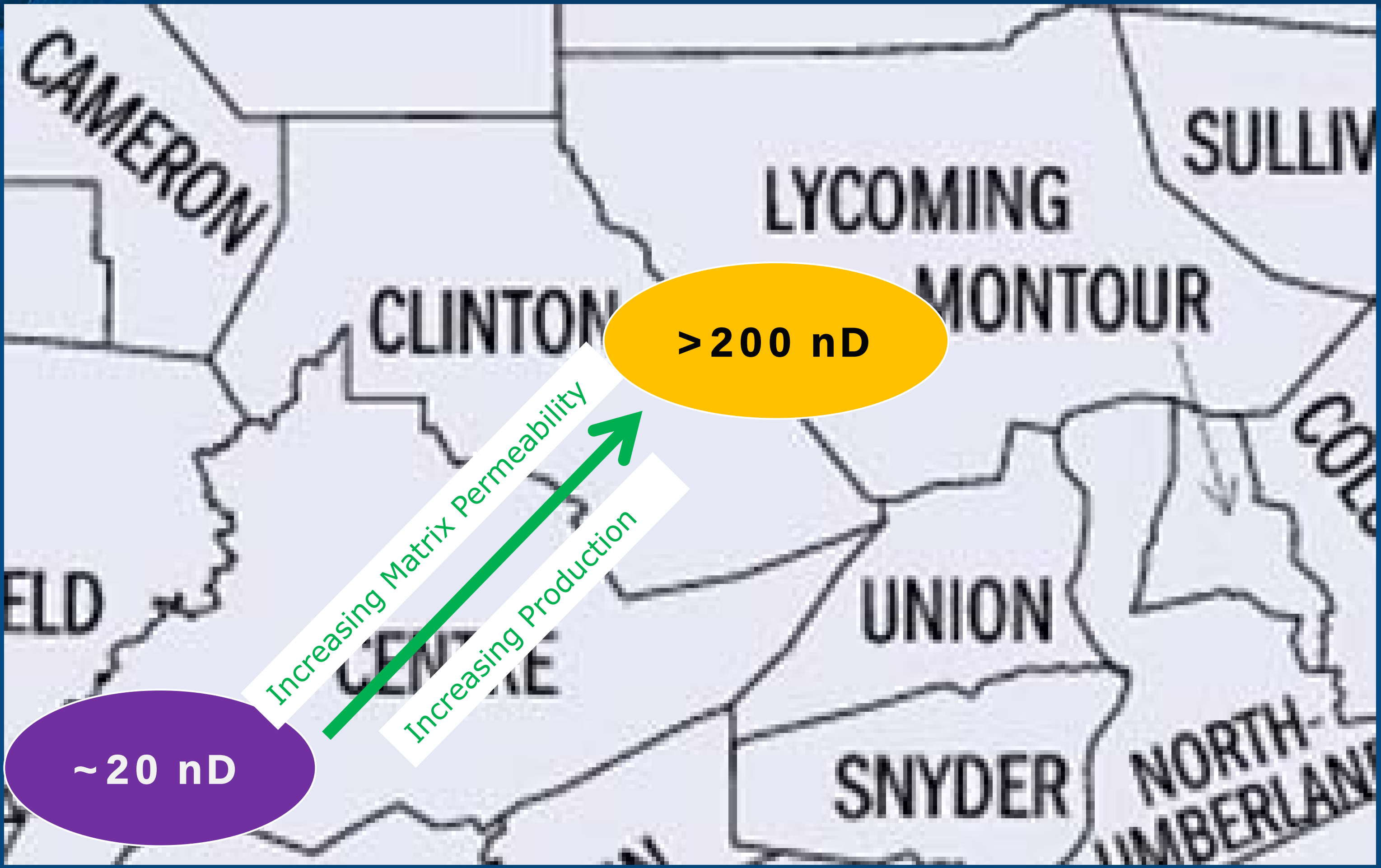
Example of Structure from Poorer Producer



Example of Production from Better Producer



Matrix Permeability (GRI)



Large increase in matrix permeability is related to improvement in production

Integration into Petroleum Systems

Seal ← Addressed by isotopic rollover

Source

Reservoir ← **Key risk**

Overburden

Key risk factor in the petroleum system should be addressed by looking at permeability and porosity

Summary

- **Isotopic rollover does not discriminate between poorer and better production in the Marcellus study area**
  - Only addresses seal and maturity

- **Using the petroleum systems method helps identify the key risk elements**
  - A great seal does not overcome poor matrix properties

- **Otherwise, we regress to drilling the bumps (or the high TOCs)**

Acknowledgements

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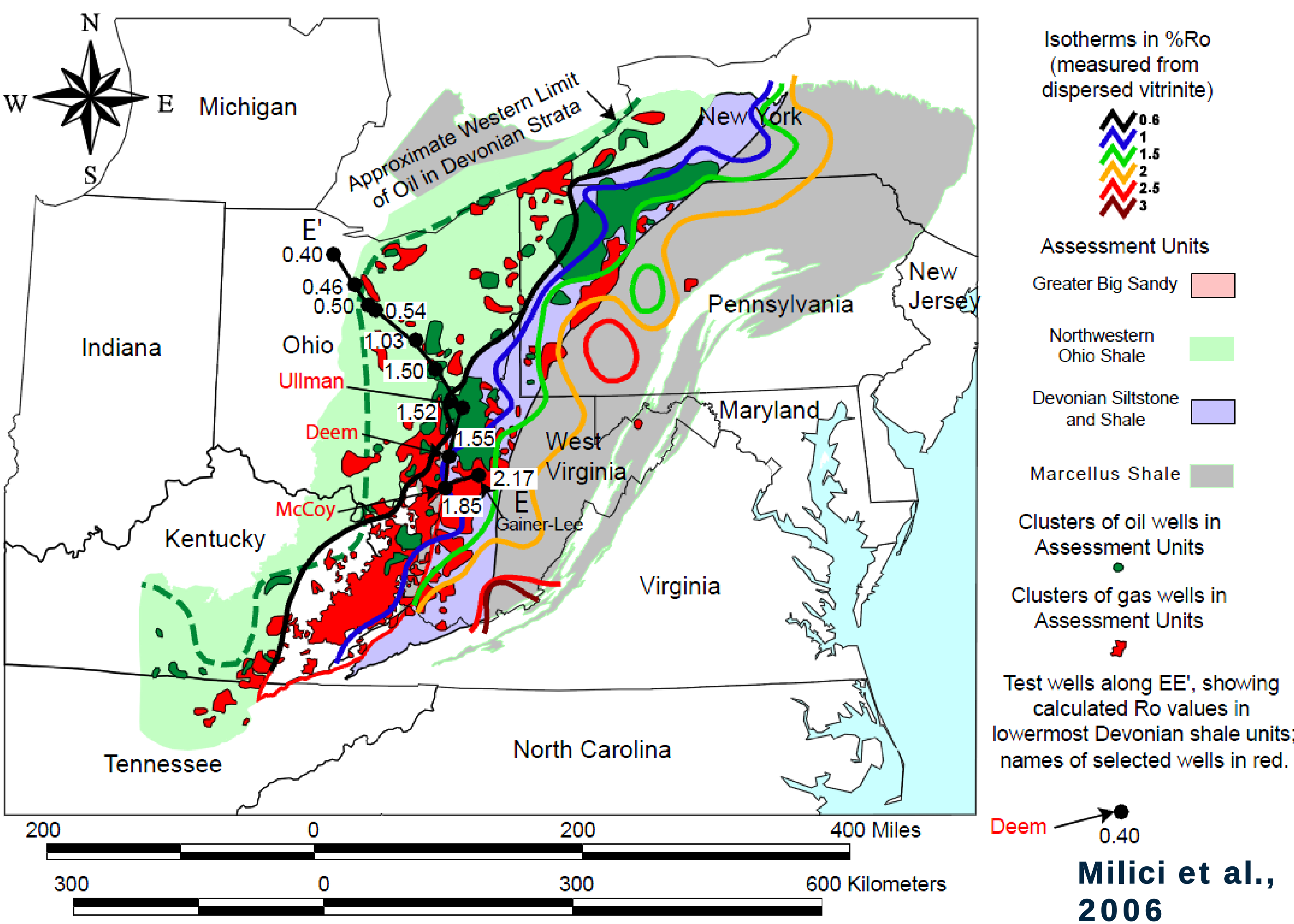
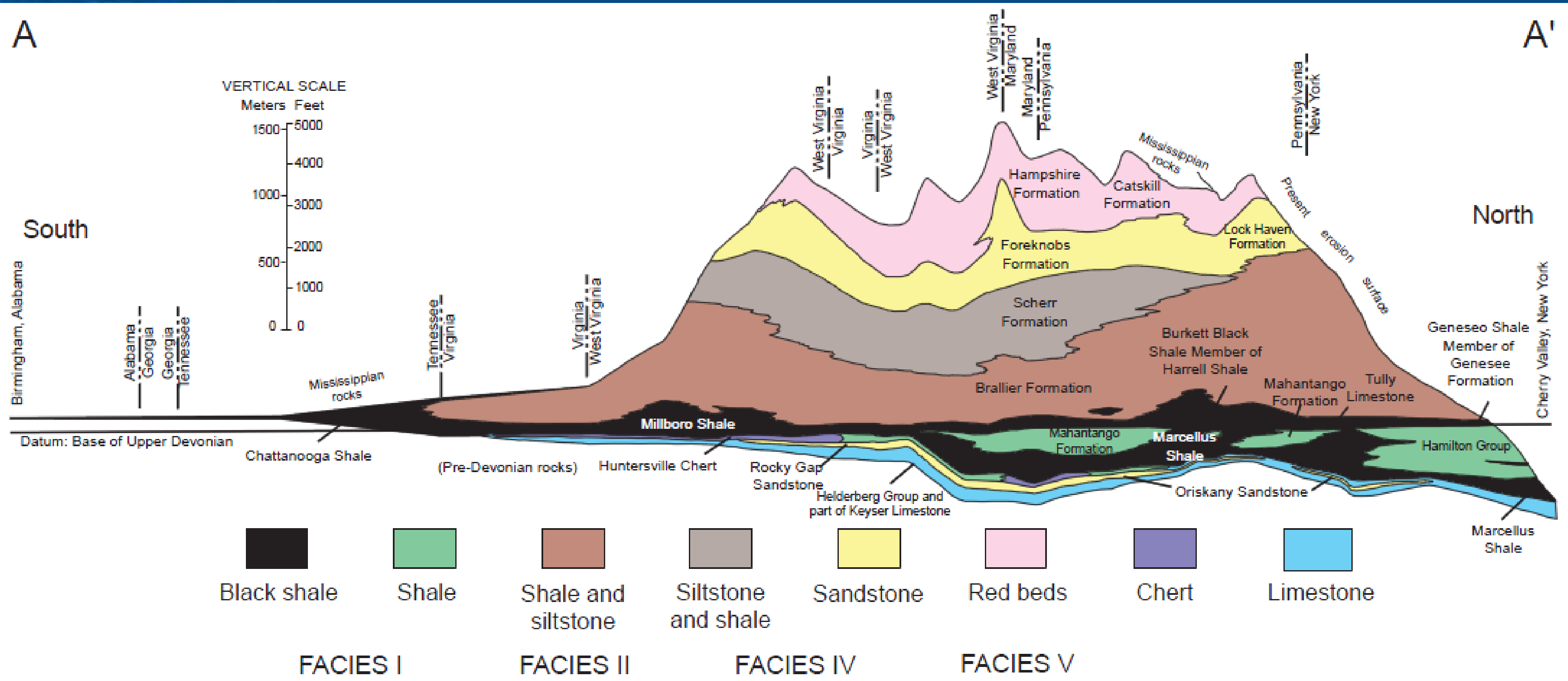
- **Marcellus development team**
  - Adam Majeski
  - Dan Tarkington
  - Kristin Walker
  - Jessica LaMarro

Extra Slides



Milici et al., 2006

Figure 11. Comparison of %Ro values calculated for wells along Appalachian cross section EE' (Rowan and others, 2004a, b) with isolines derived from dispersed vitrinite data (Repetski and others, 2002, 2005; Weary and others, 2000, 2001).



Milici et al., 2006
after de Witt, 1975 and Harper 1999