

PS Cross-comparison of Stacked Unconventional Plays of Delaware and Appalachian Basins: Reservoir Characteristics and Production Profiles*

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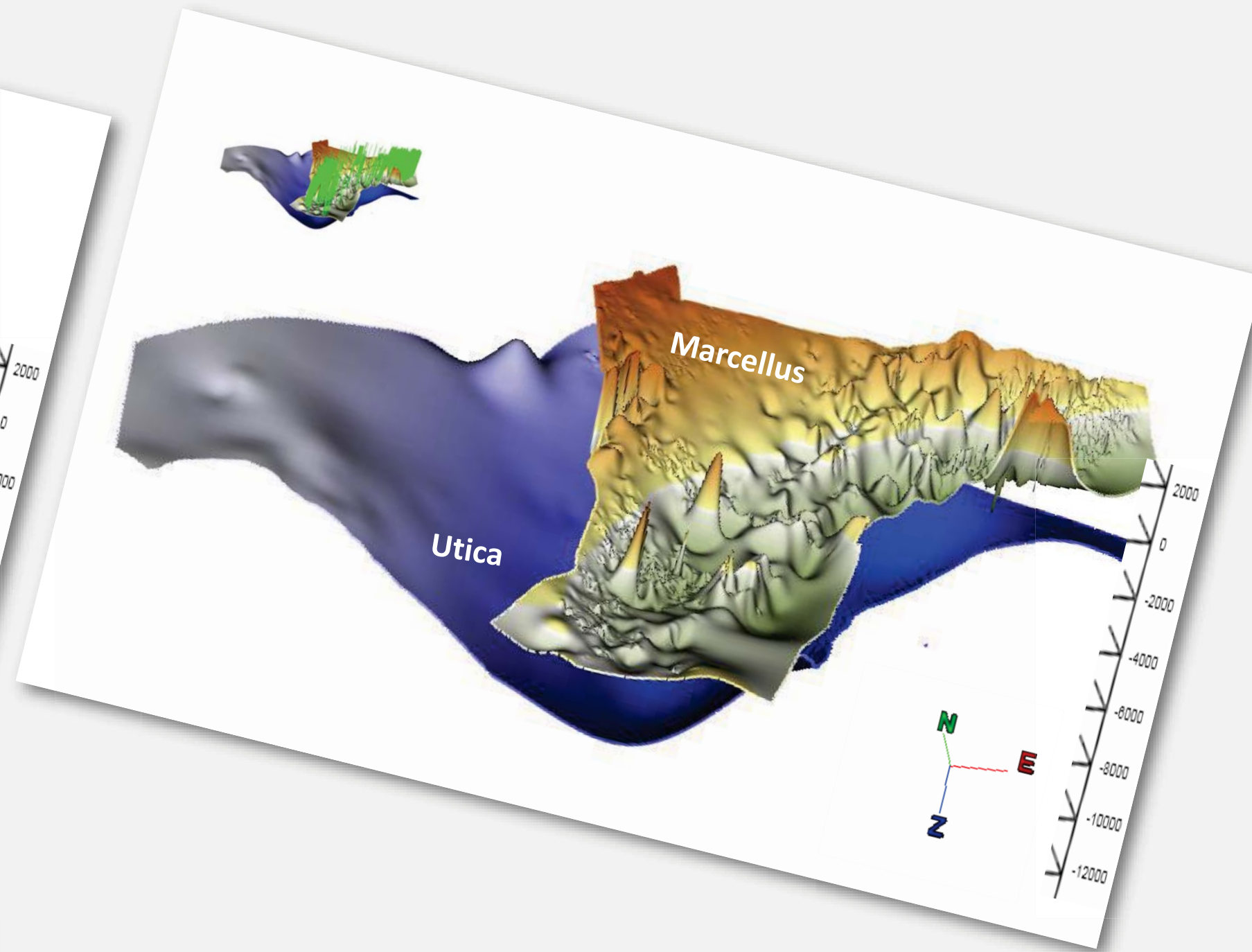
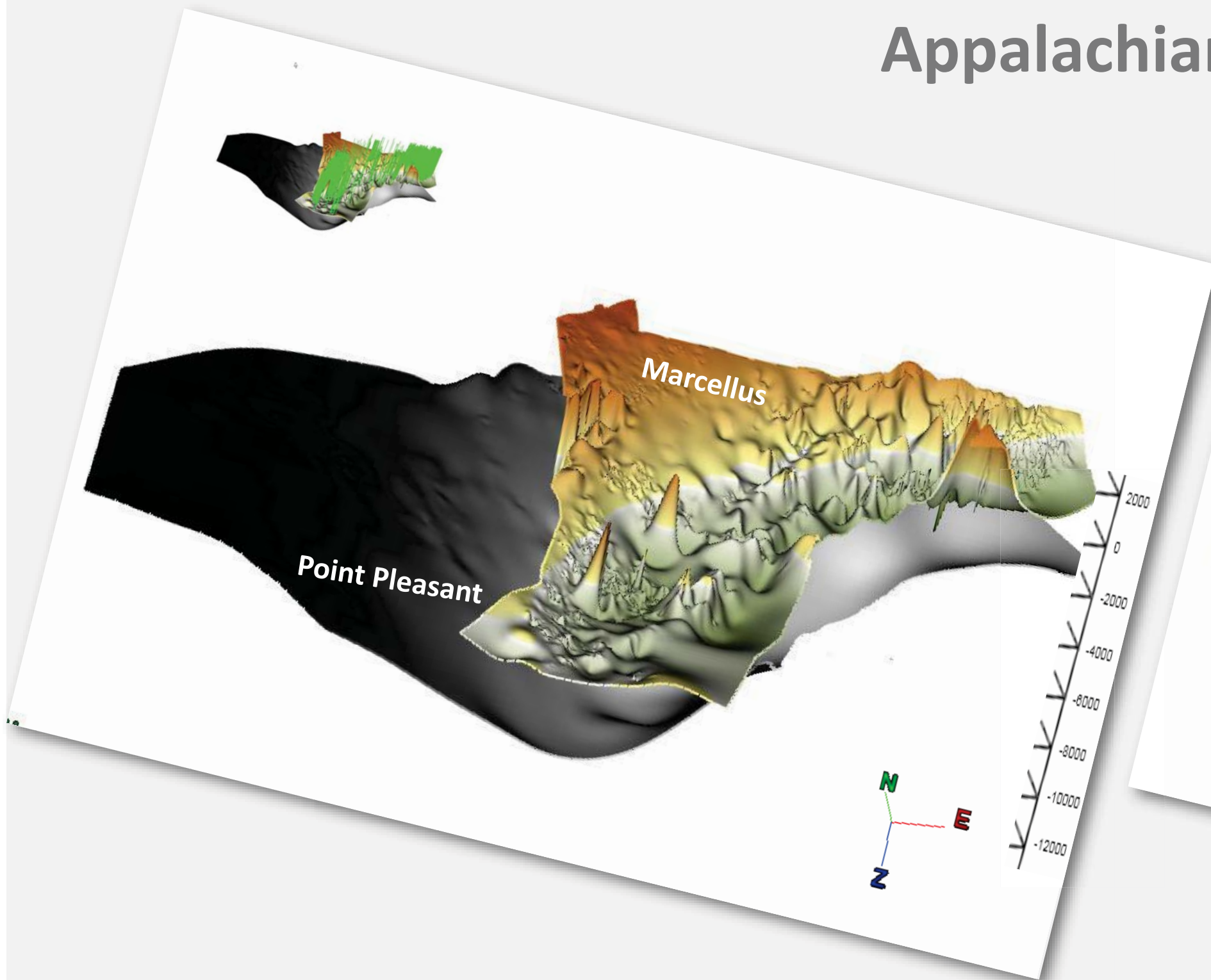
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Abstract

Increasing drilling and completion operations within the Wolfcamp and Bone Spring plays are responsible for much of the crude oil and associated natural gas production growth in the Permian Basin since 2005. In 2018 Wolfcamp and Bone Spring accounted for about 1.8 million barrels of crude oil per day (MMb/d) (about 14% of total U.S. oil production), and almost 5.5 billion cubic feet of natural gas per day (Bcf/d) (about 4 % of total U. S. gas production). According to EIA's Annual Energy Outlook 2018 (Reference case) domestic crude oil production is expected to grow through 2040 mainly due to continuing development of unconventional reservoirs of the Permian basin, including Wolfcamp and Bone Spring Play. Natural gas production from shale formations in the Appalachia region has increased rapidly since 2012, driving an overall increase in U.S. production. In 2018 Marcellus and Utica/Point Pleasant plays generated 25.9 Bcf/d of dry natural gas, or 31% of total U.S. production. According to EIA's Annual Energy Outlook 2018 Reference case Natural gas production from shale plays is expected to increase through 2040. Both Appalachian shale plays have remained resilient to the low natural gas prices and are projected to continue to drive total U.S. production in the long term. The U.S. Energy Information Administration (EIA) is in the process of updating maps of the major tight oil and shale gas plays of the lower 48 states using publicly available geologic data and a commercial well-level database. Thematic and production maps for Eagle Ford, Bakken, Marcellus, Utica, Wolfcamp and Bone Spring plays have recently been published at the EIA Maps webpage. Play maps for the eastern part of the Permian basin including the Midland basin and Central Basin Platform are under construction. Additional maps are also planned for the remaining major oil and natural gas plays for which sufficient well, production, and geologic data are available. Side-by-side comparison of maps, cross-sections, and production profiles shows similarities and differences across Appalachian and Delaware basin stacked play characteristics and production profiles. E.g. two basins have factors favorable for production including proximity to consuming markets and established infrastructure. Drilling wells in the Appalachia and Delaware regions has become very productive. EIA attributes increase in hydrocarbon production in these two regions to efficiency improvements in horizontal drilling and hydraulic fracturing, which include faster drilling, longer laterals, advancements in technology, and better targeting of wells. E.g., in the Appalachian basin, the average lateral length per well has increased from about 2,500 feet in 2007 to more than 9,000 feet in 2018. Some operators have recorded lateral lengths as long as 18,000 feet in the Marcellus and 19,000 feet in the Utica. Along with longer horizontal drilling, the days it takes for completion have decreased from about 30 days in 2011 to 4 days in 2018.

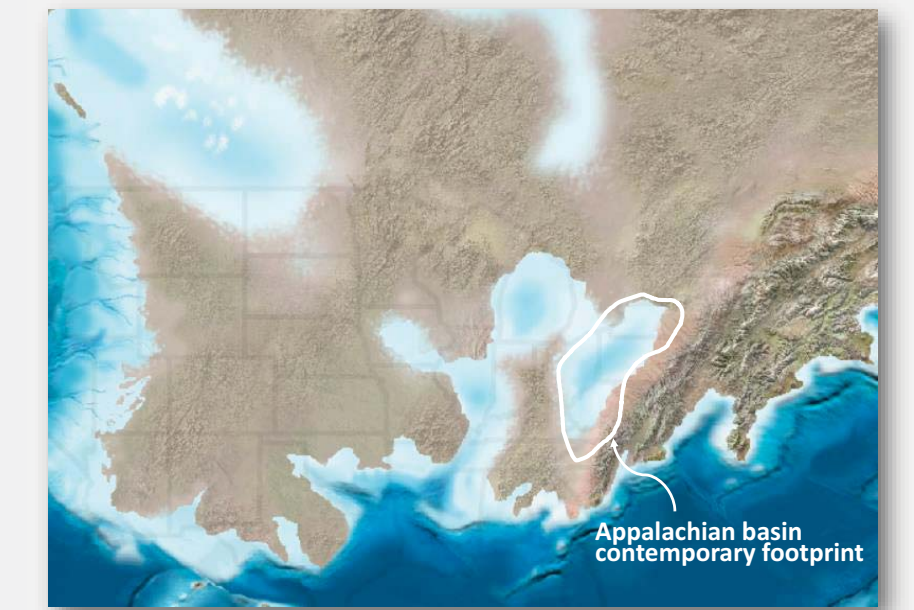
Appalachian basin



Paleogeographic reconstructions

exhibiting the no part of North America.

Modified after Blakey (2011)
Middle Devonian (385 Ma)

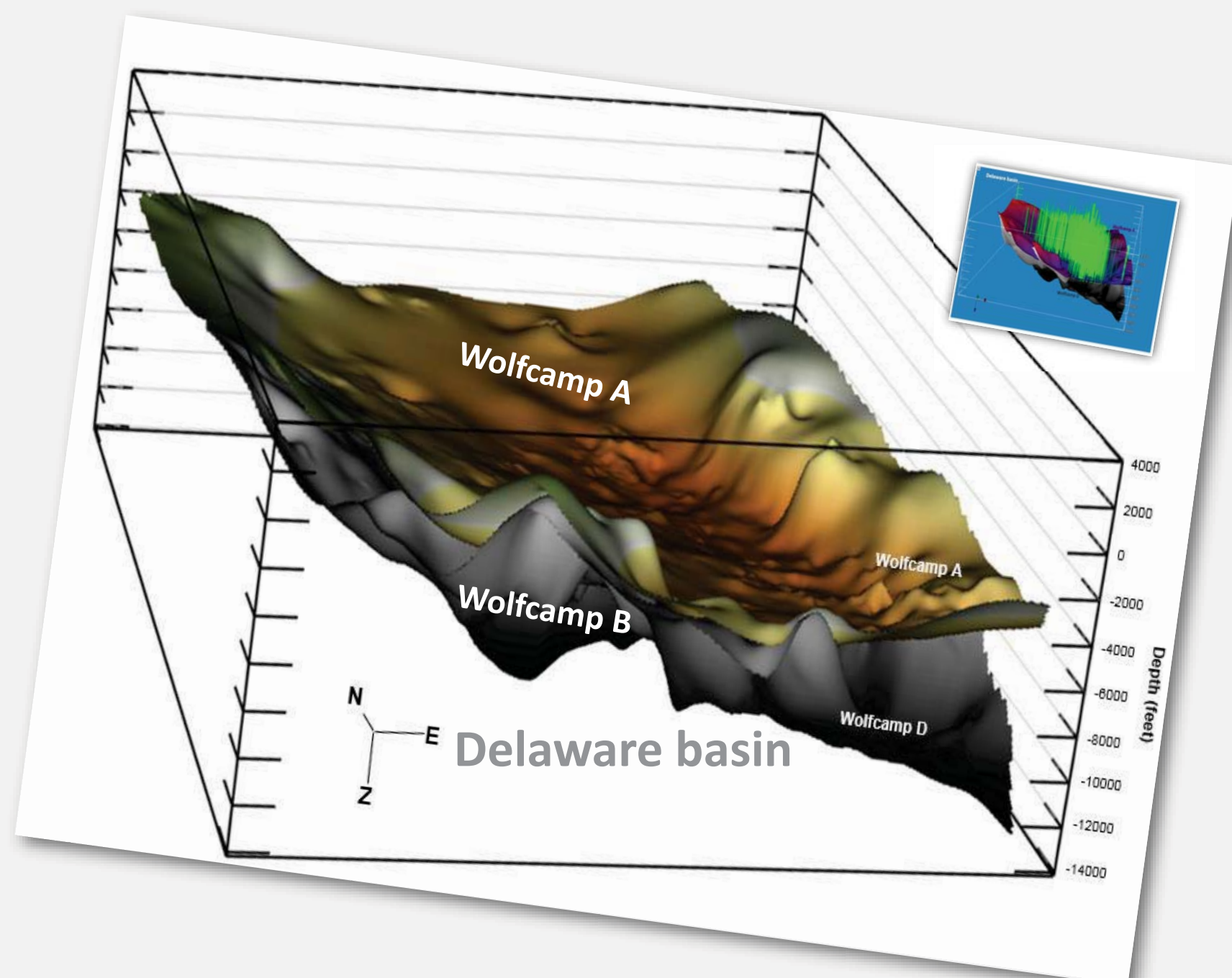


Late Ordovician (445 Ma)

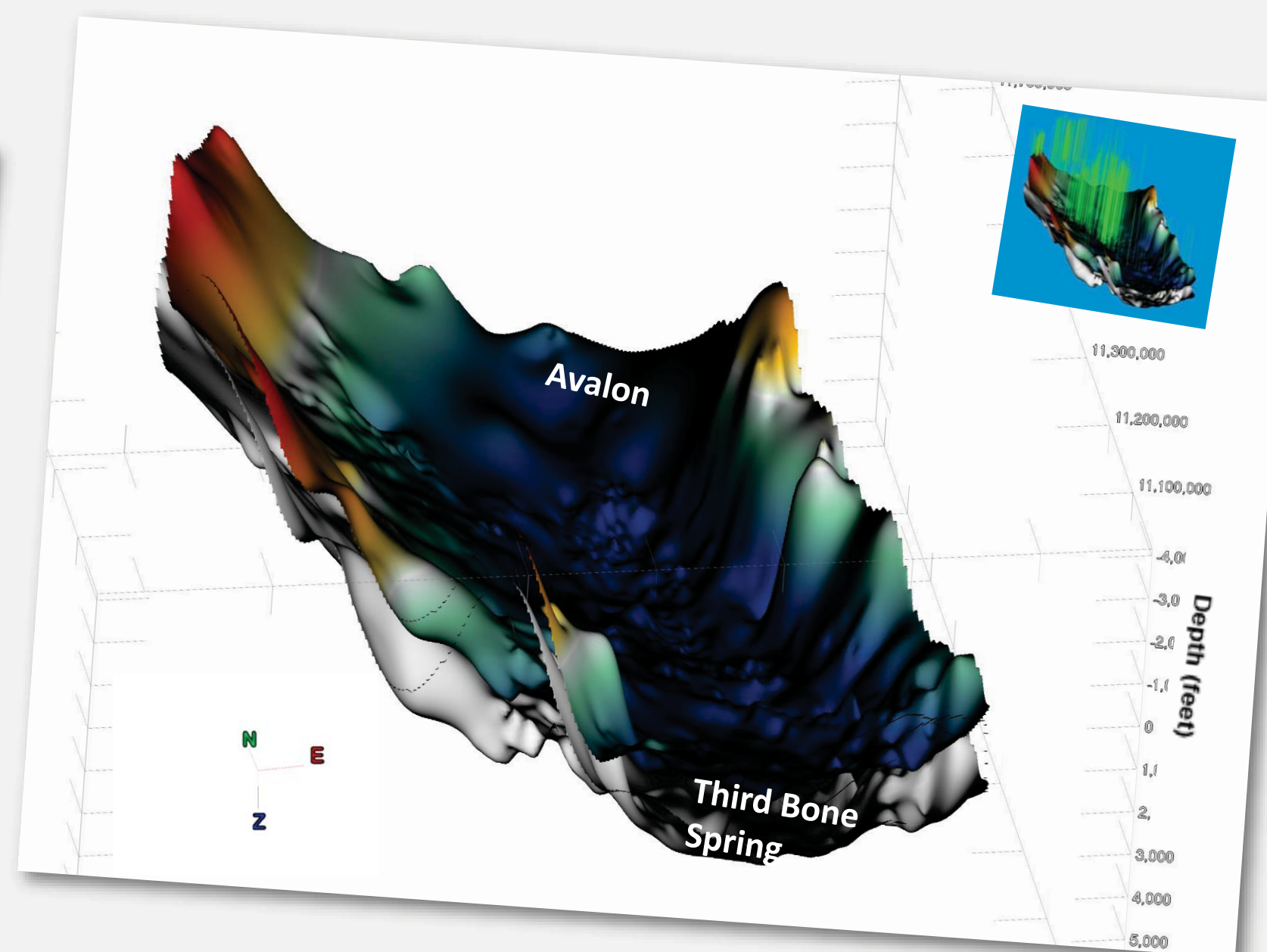


Delaware basin

Wolfcamp 3-D Model



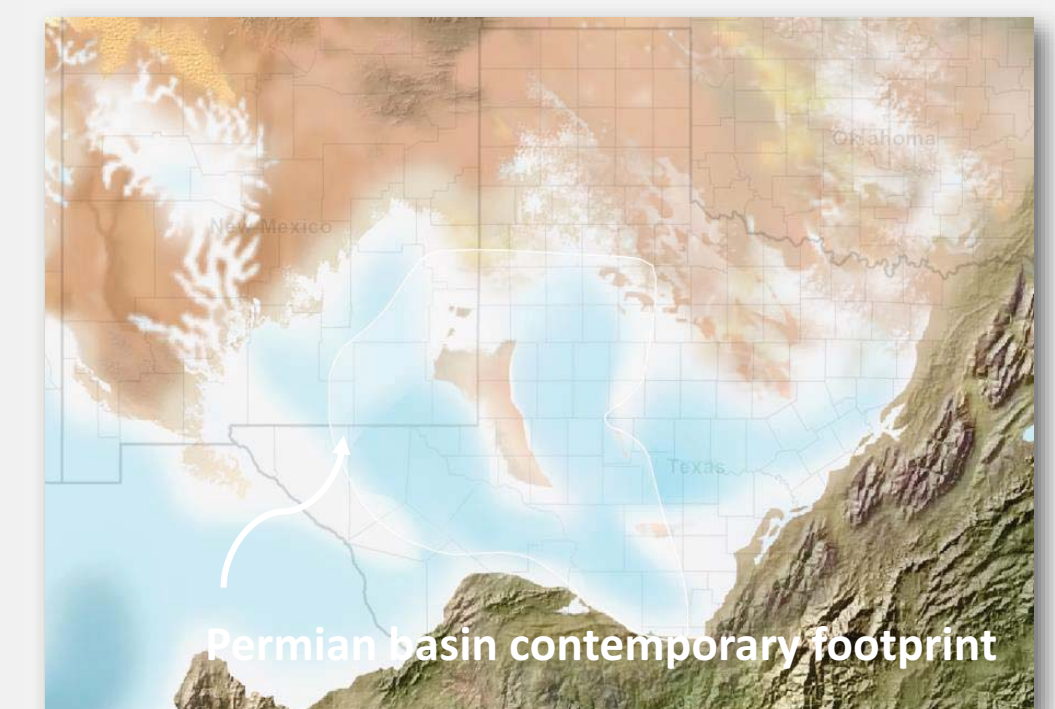
Bone Spring 3-D Model



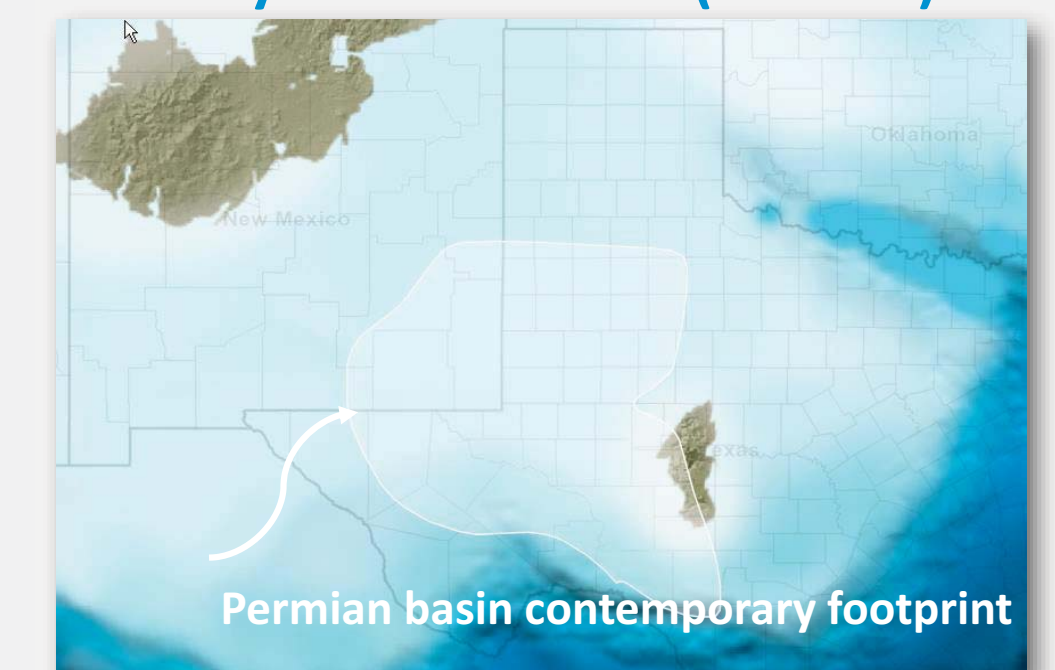
Paleogeographic reconstructions

exhibiting the southern part of North America.

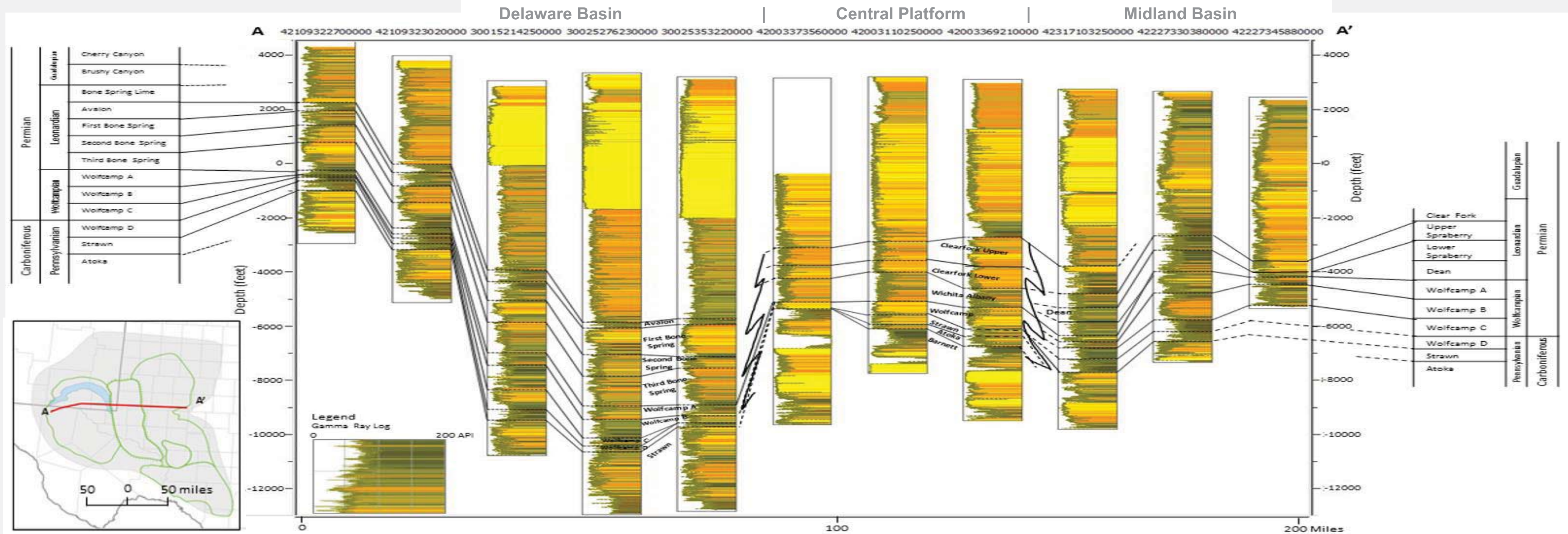
Modified after Blakey (2011)
Early Permian (280 Ma)



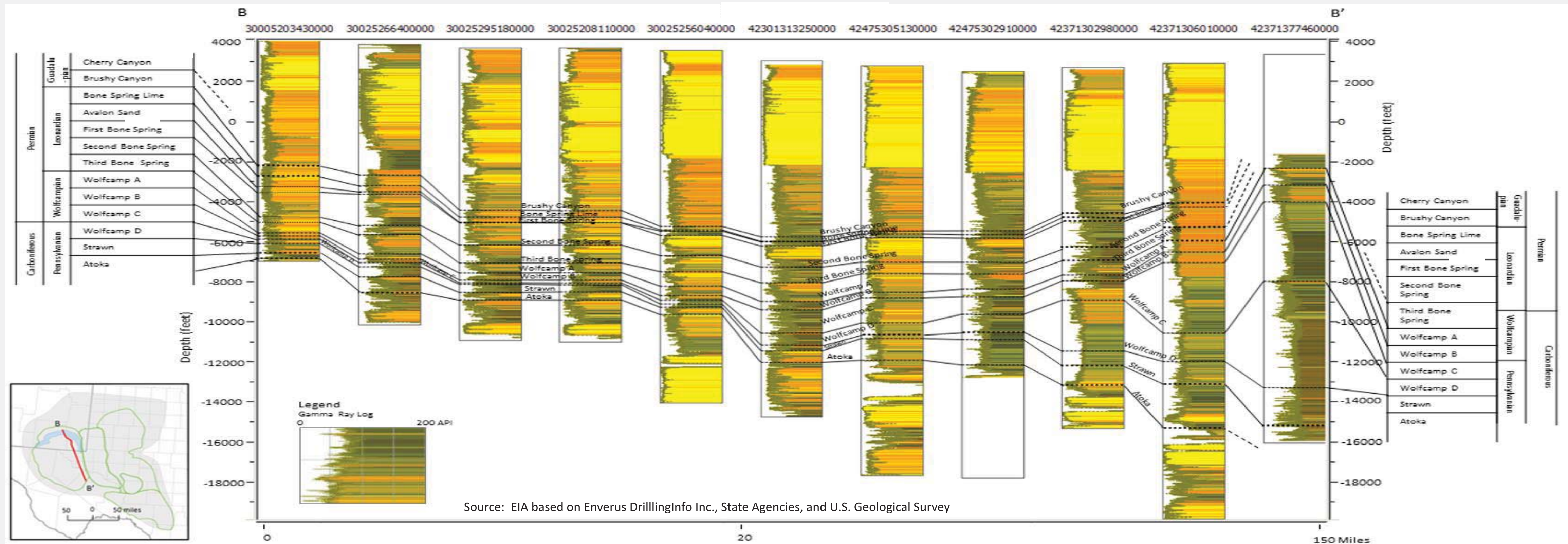
Early Carboniferous (345 Ma)



East to West geological cross section through the Permian basin

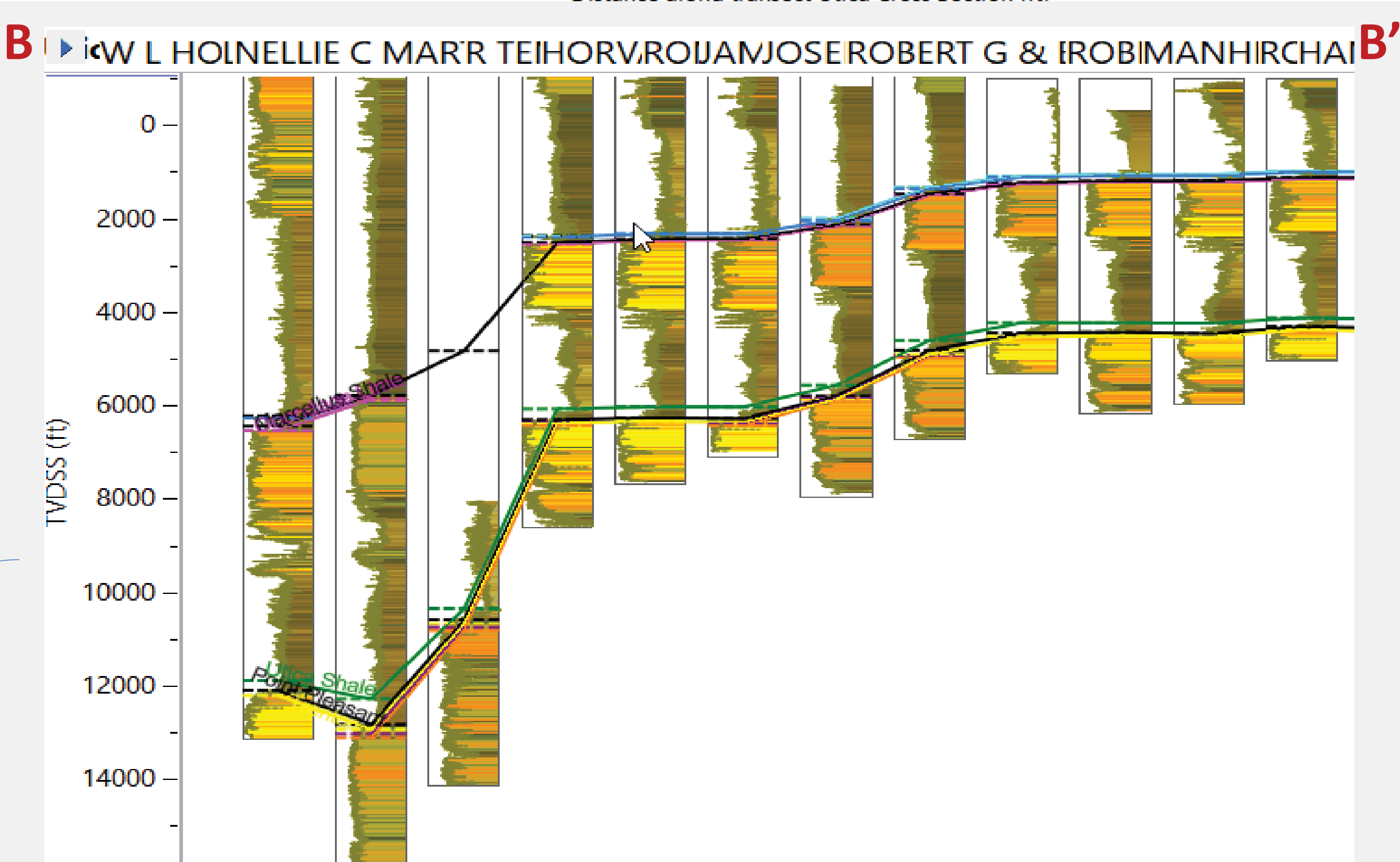
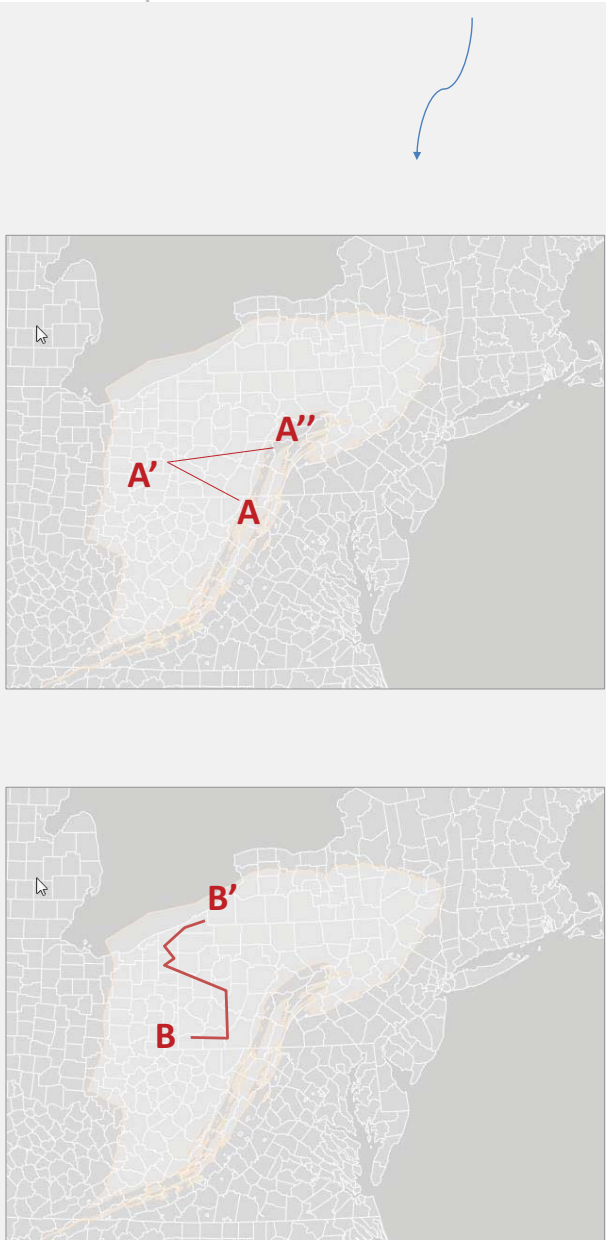
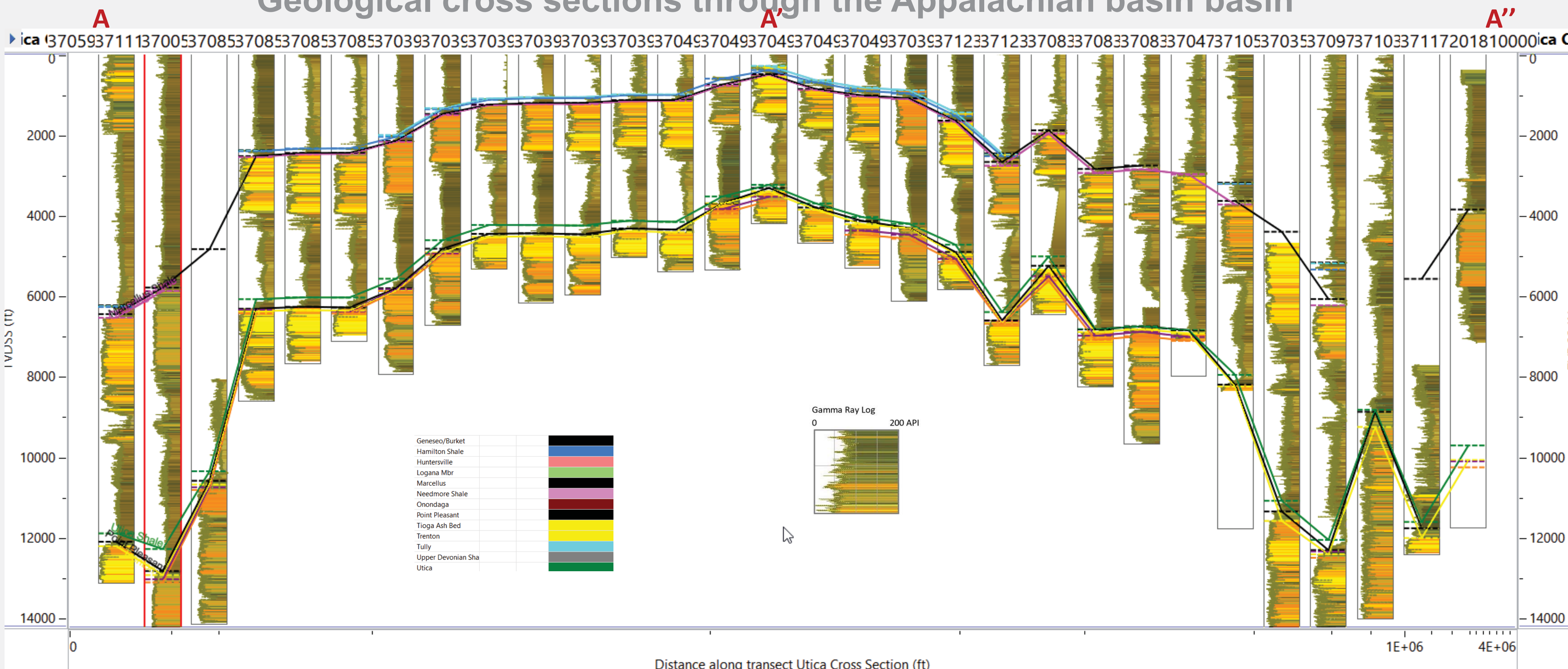


North to South geological cross section through the Delaware basin



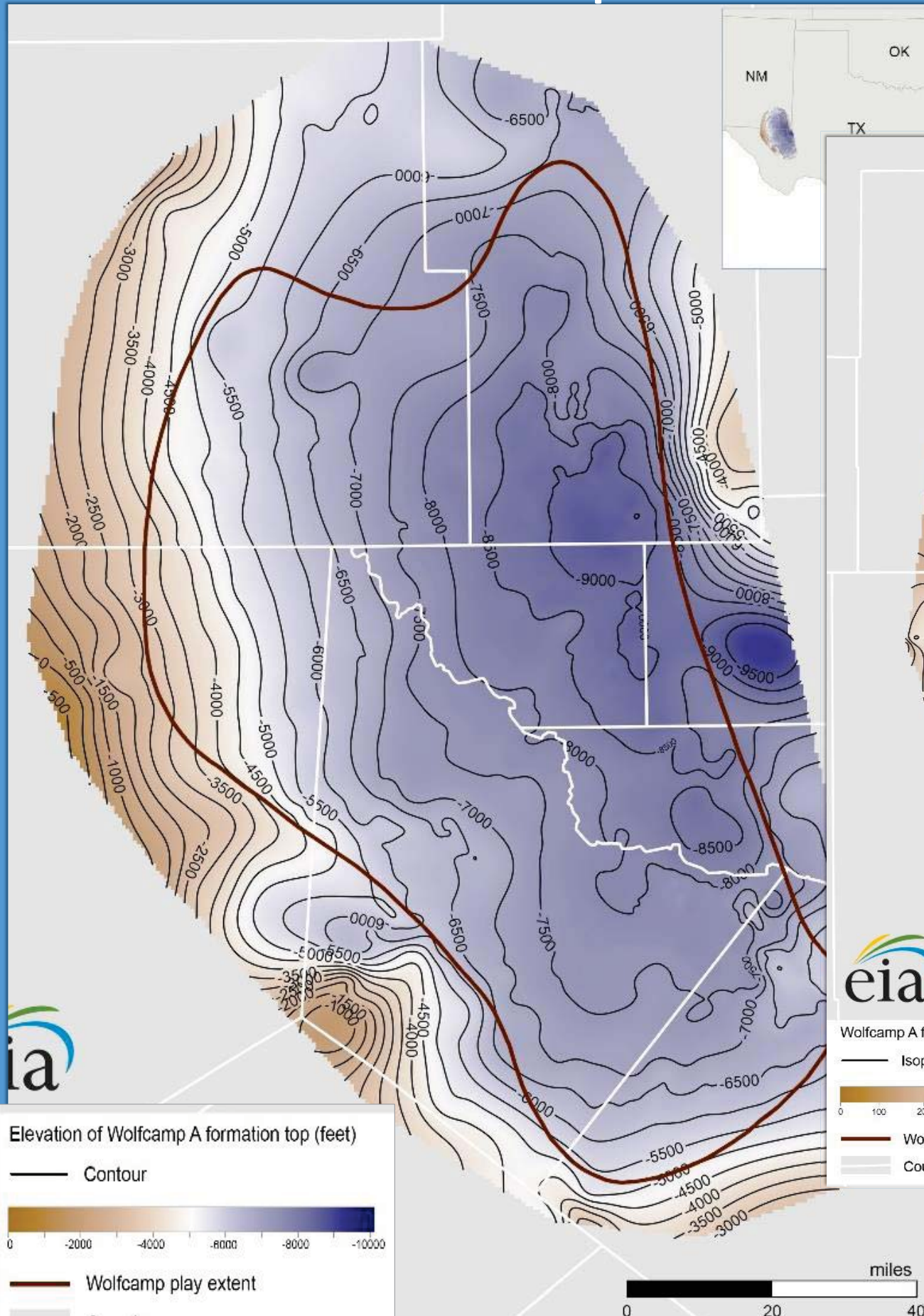
Source: EIA based on Enverus DrillingInfo Inc., State Agencies, and U.S. Geological Survey

Geological cross sections through the Appalachian basin

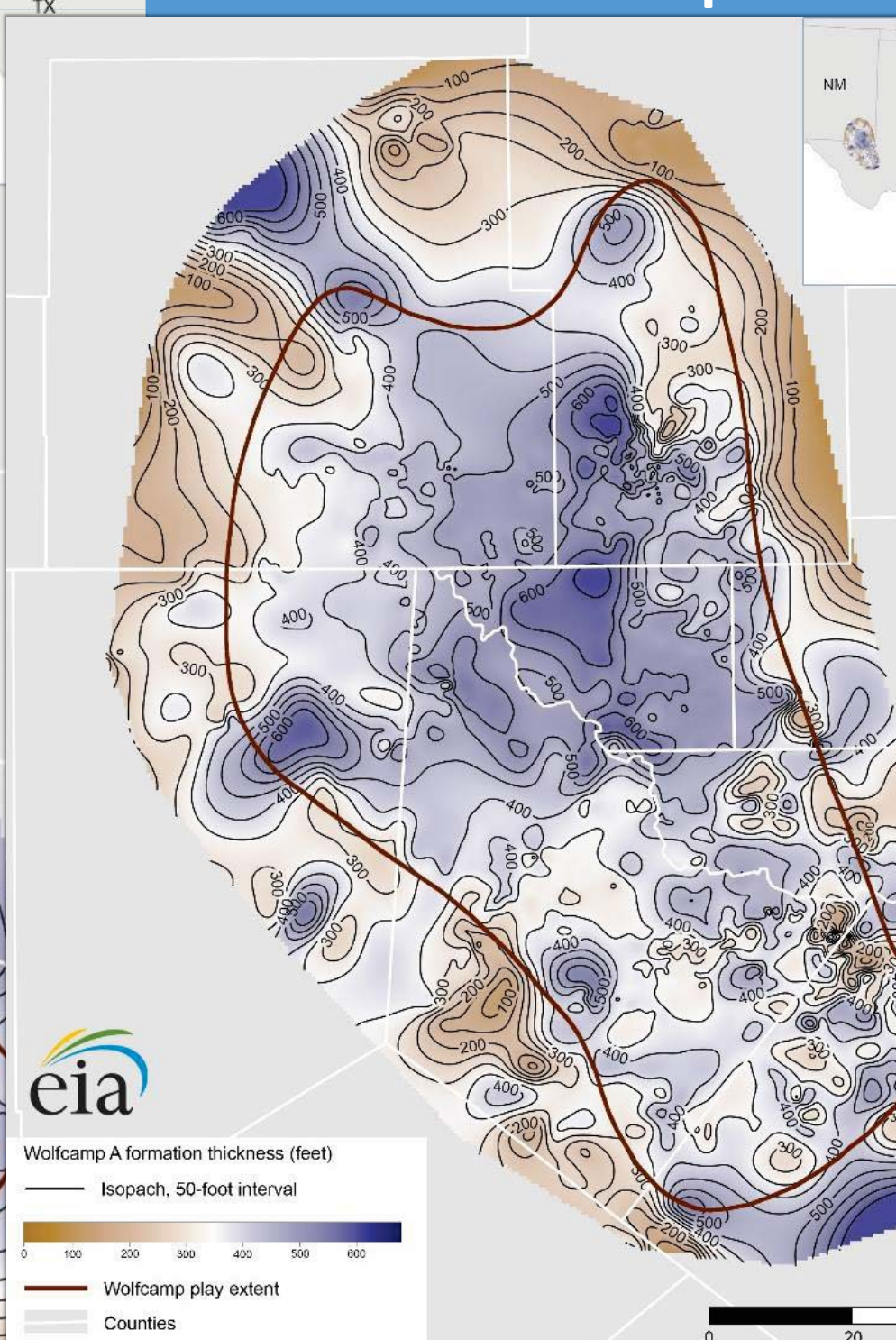


Wolfcamp A, Delaware Basin

Structure map

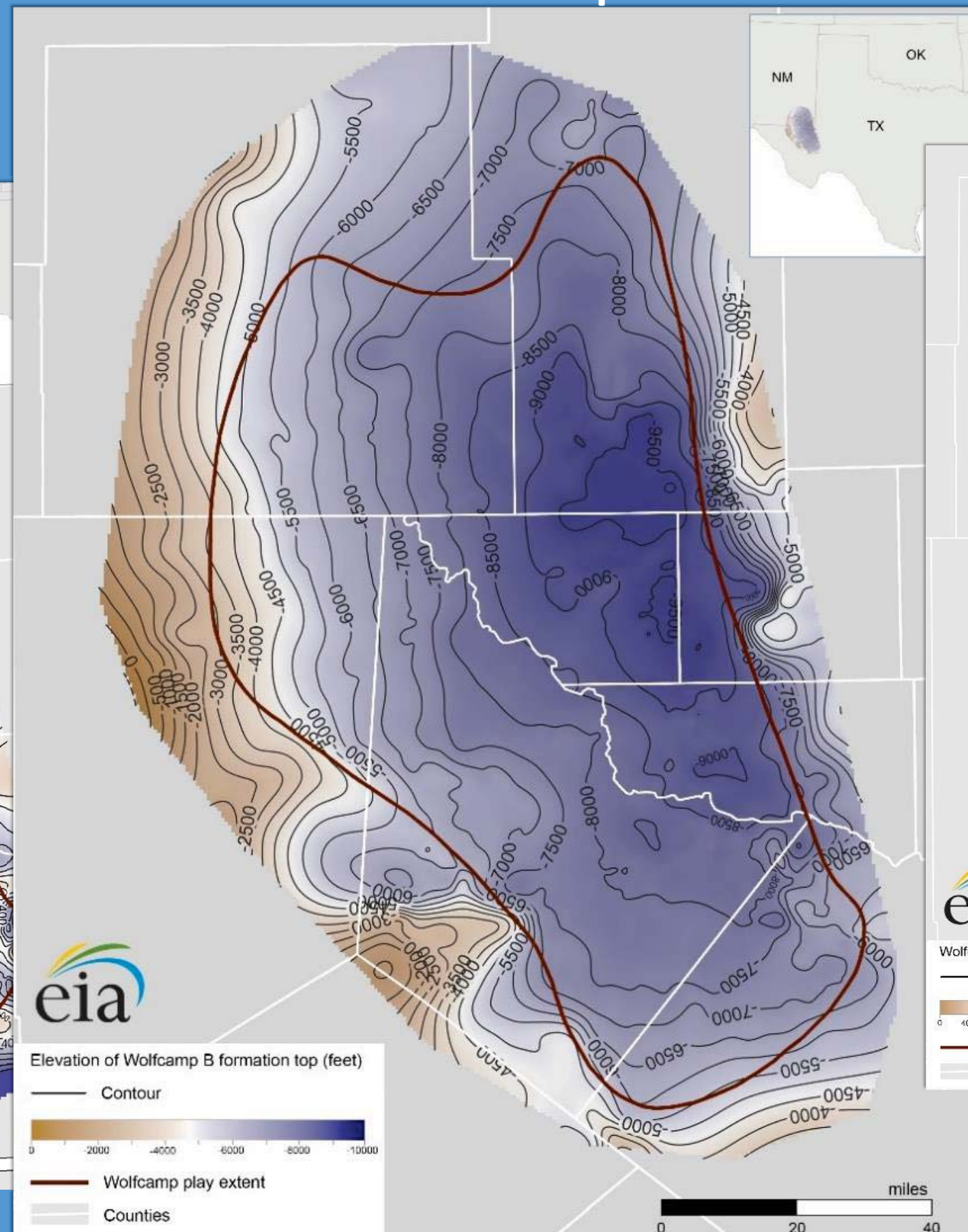


Thickness map

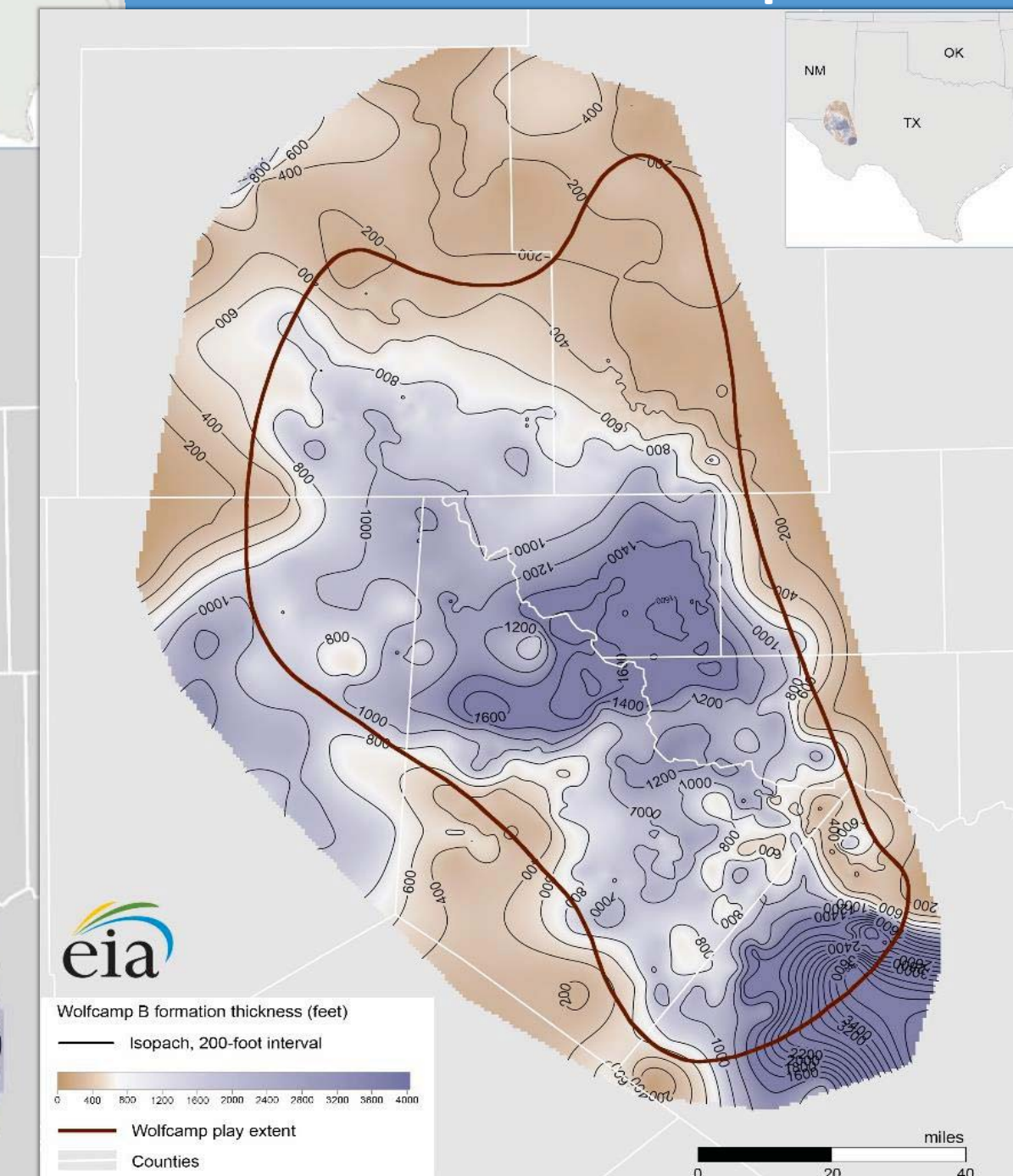


Wolfcamp B, Delaware Basin

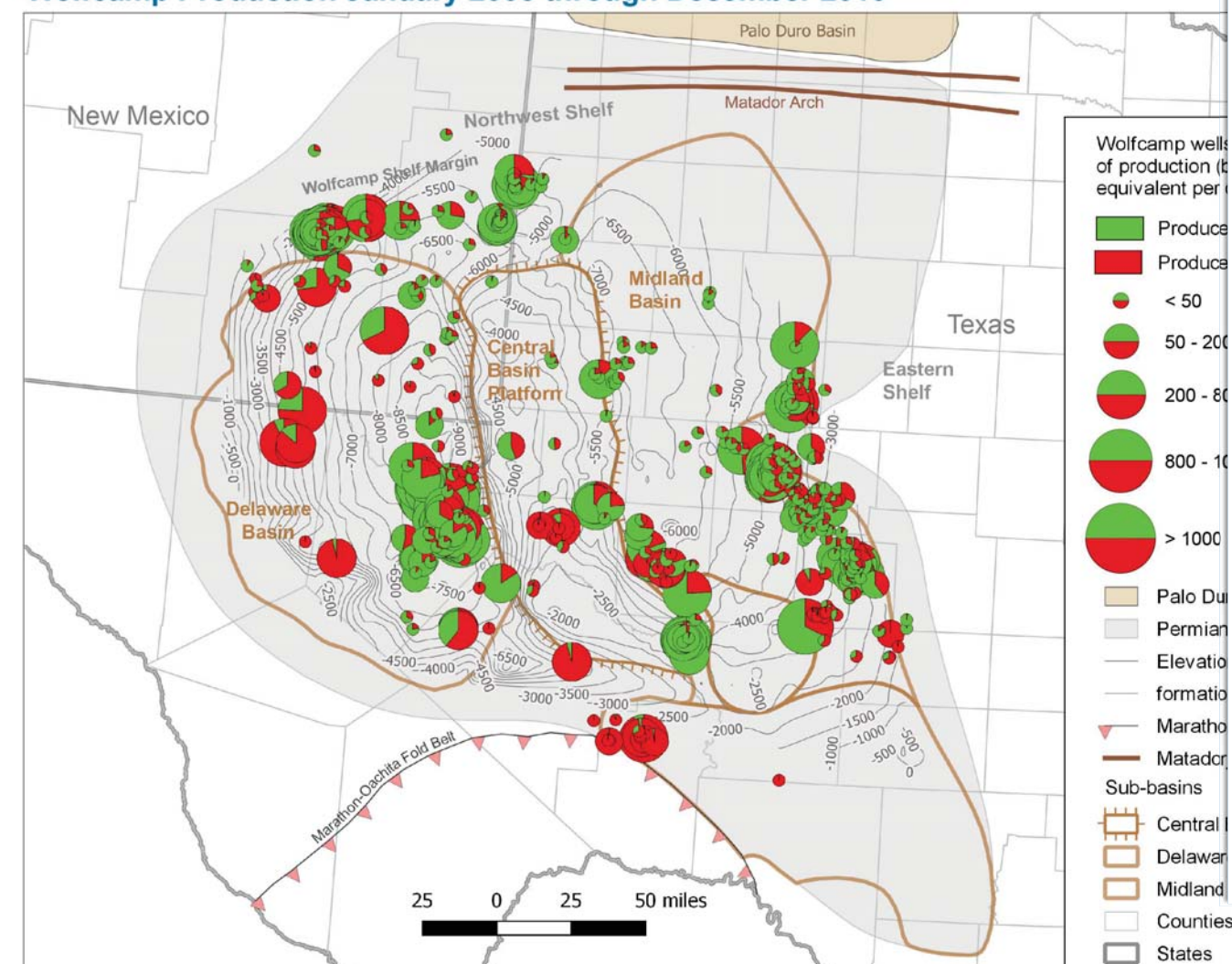
Structure map



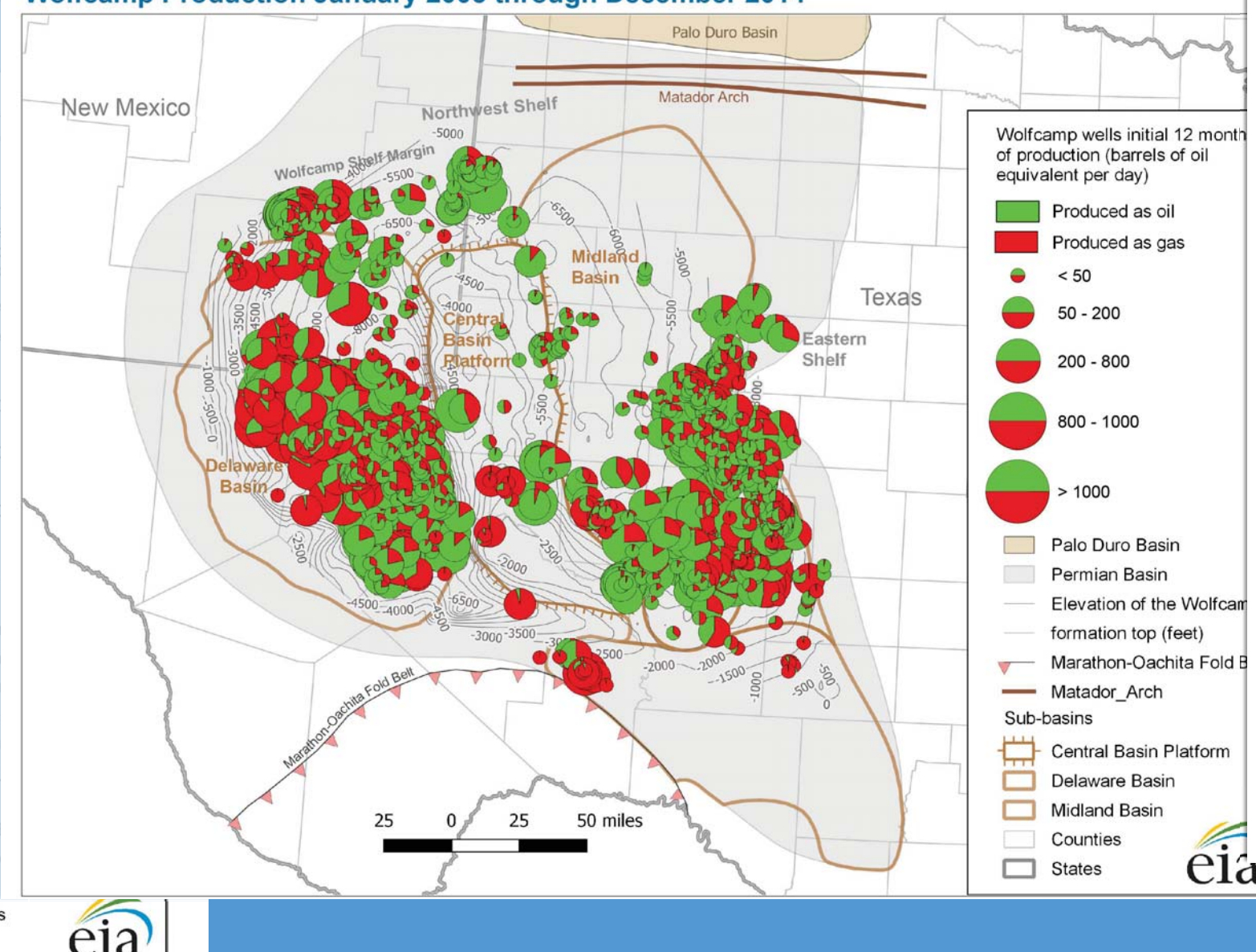
Thickness map



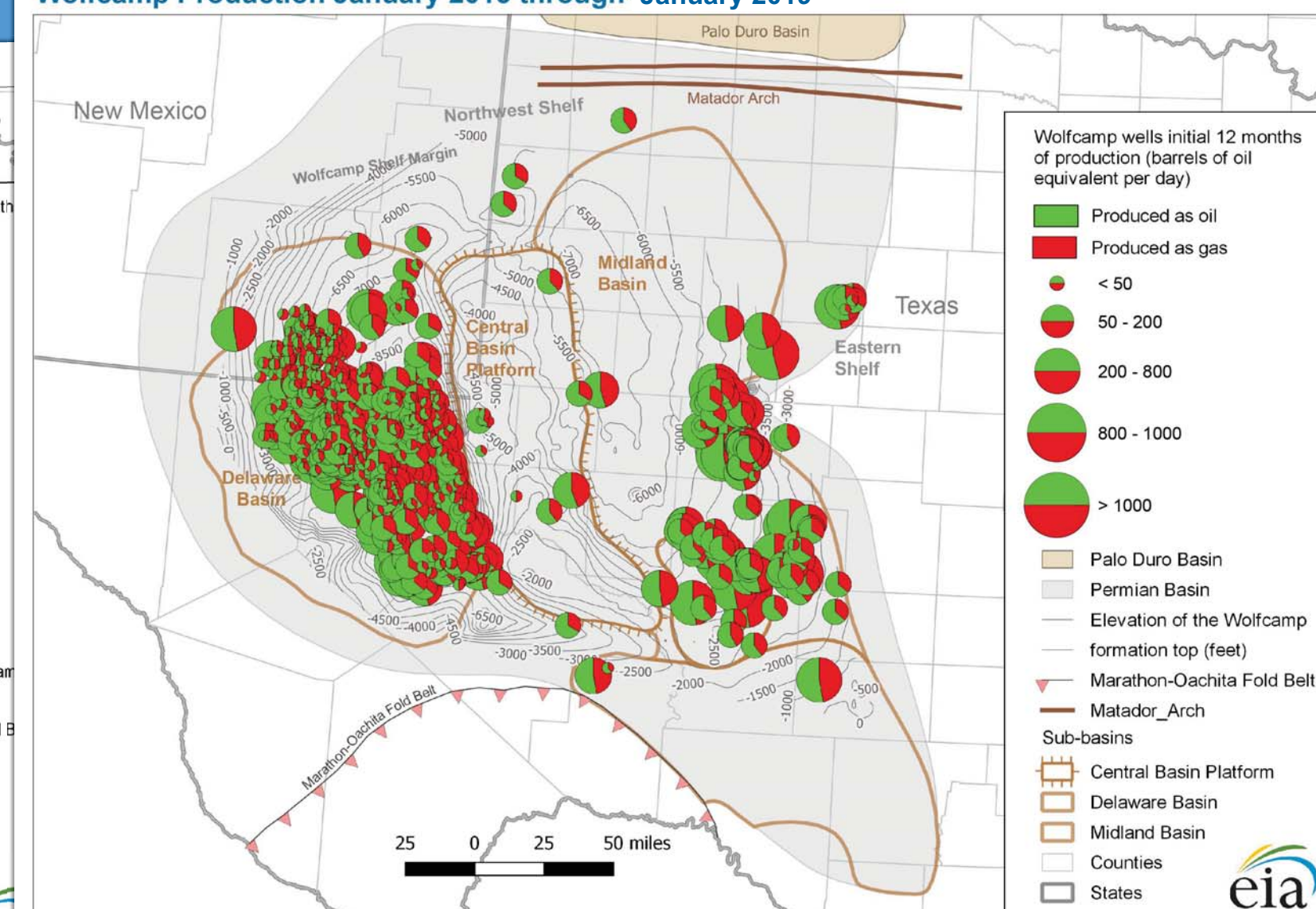
Wolfcamp Production January 2005 through December 2010



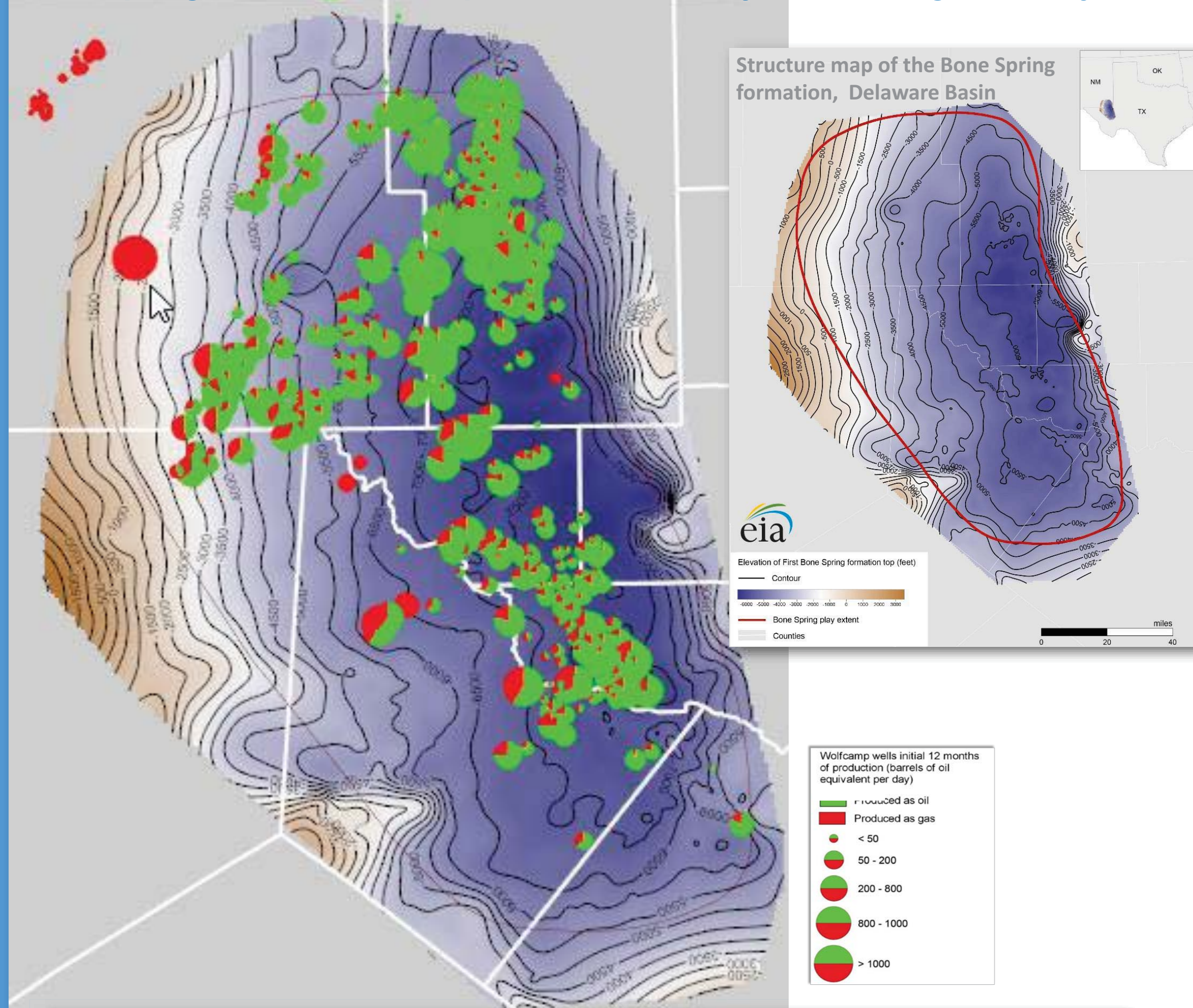
Wolfcamp Production January 2005 through December 2014



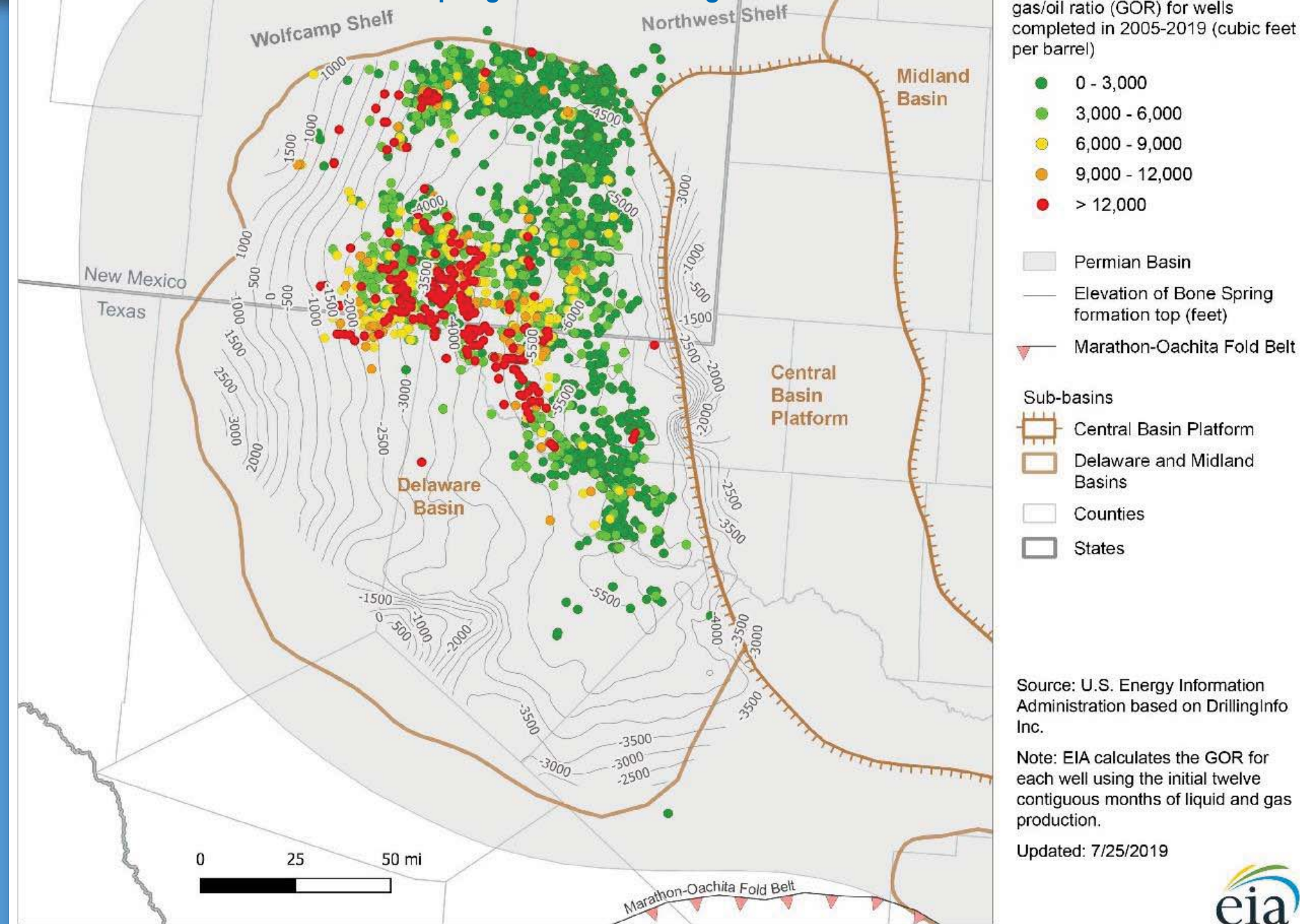
Wolfcamp Production January 2015 through January 2019



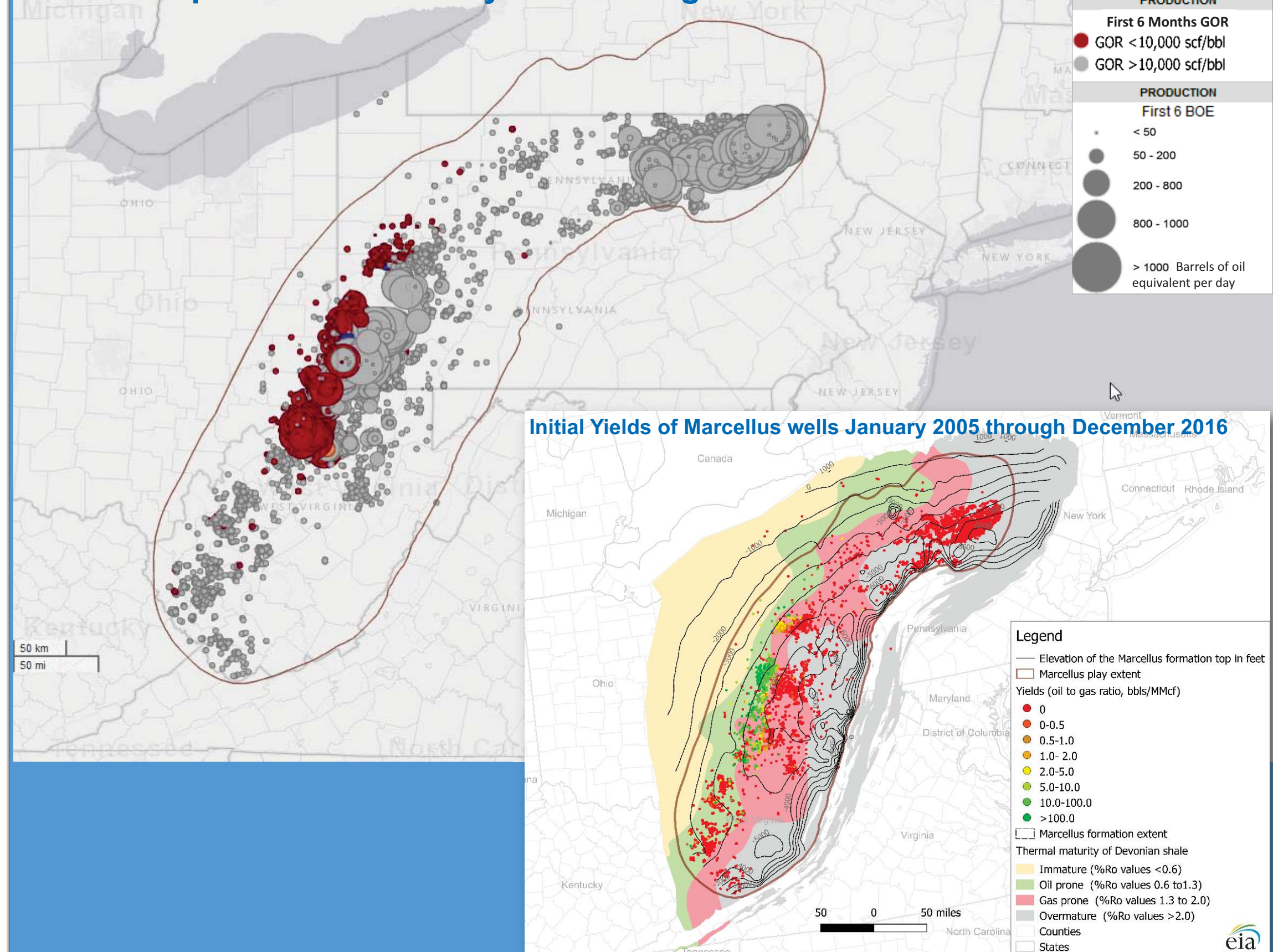
Bone Spring, Delaware Basin production January 2008 through January 2019



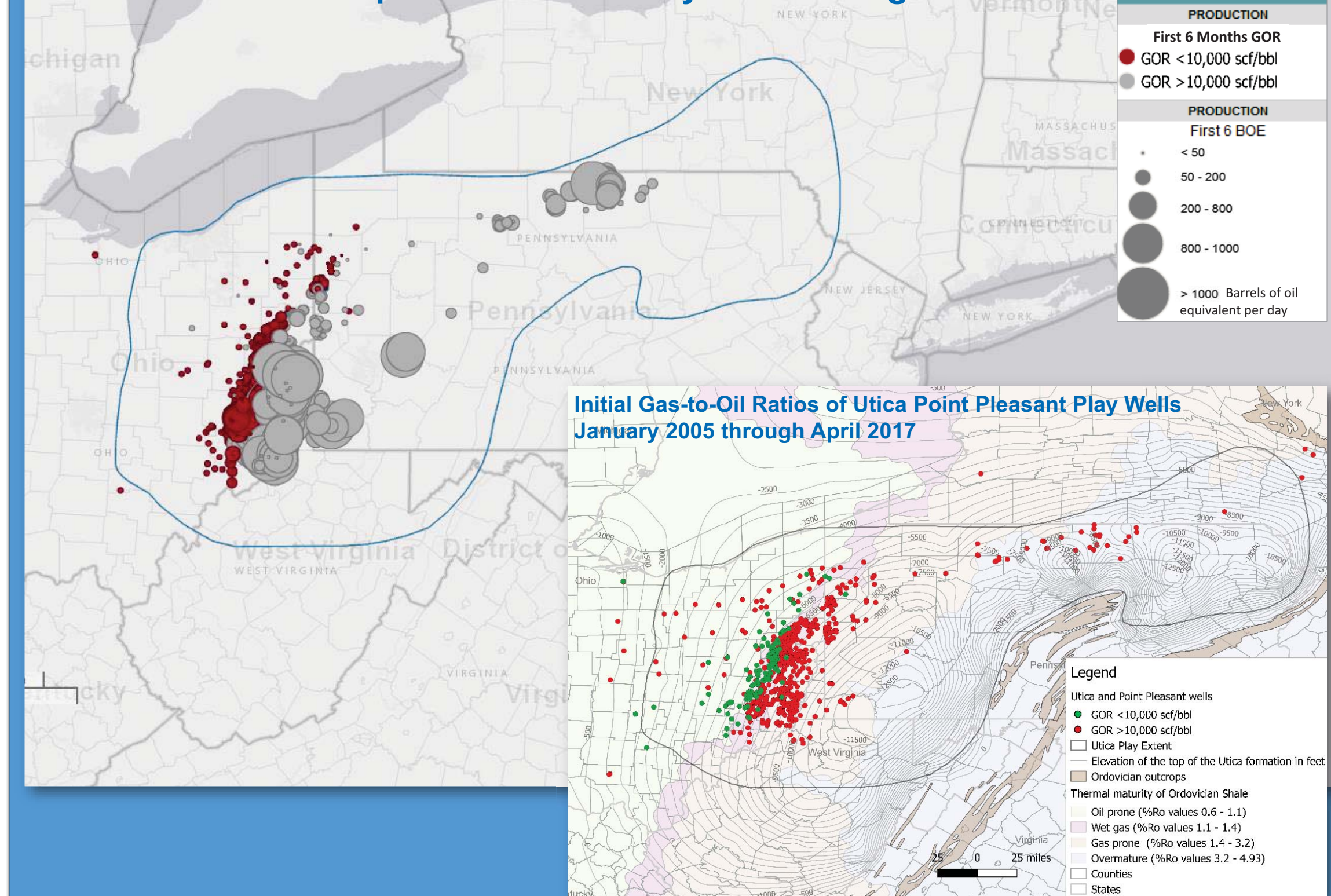
Initial Gas-to-Oil Ratios of Bone Spring Wells 2005 through June 2019



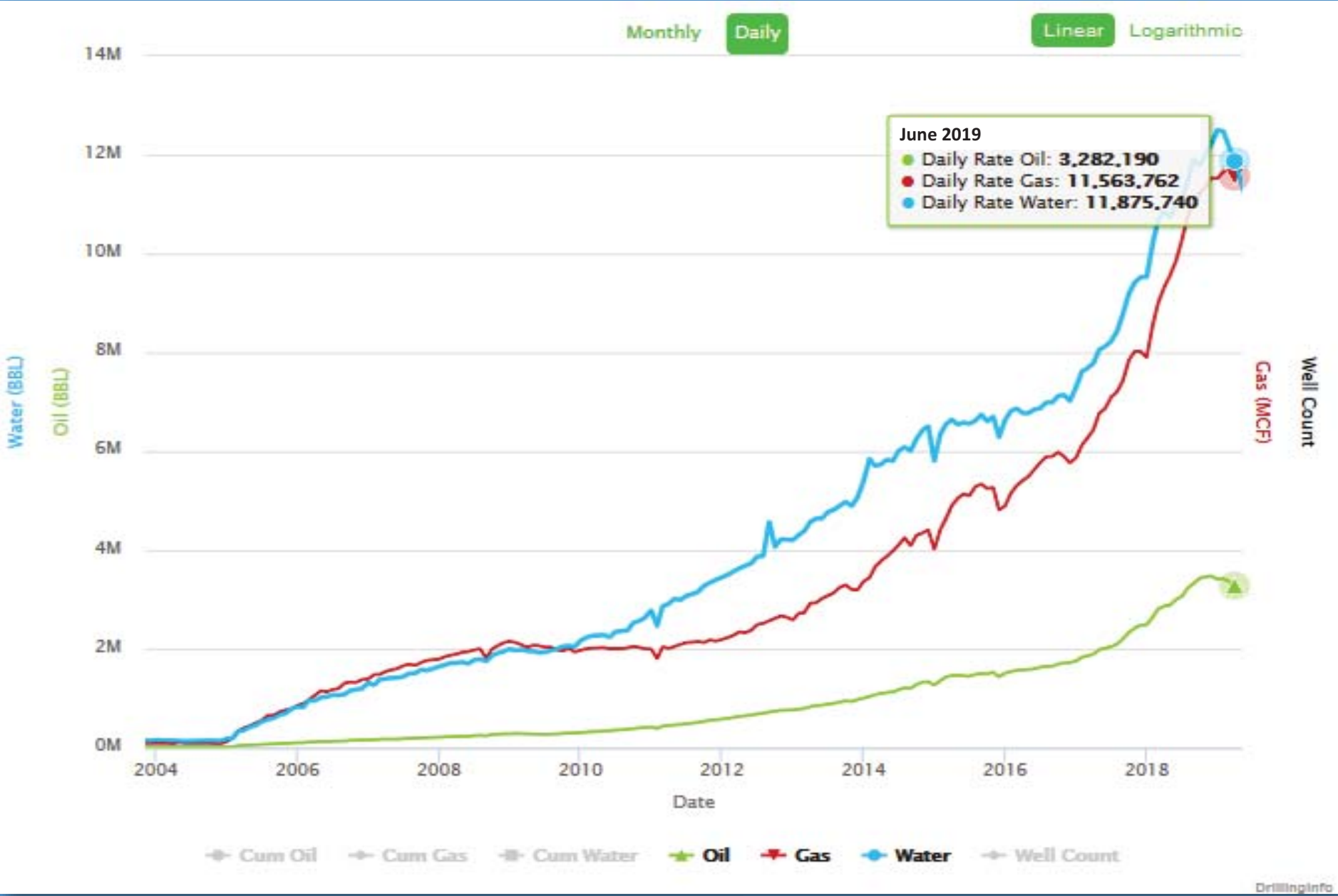
Marcellus production January 2005 through June 2019



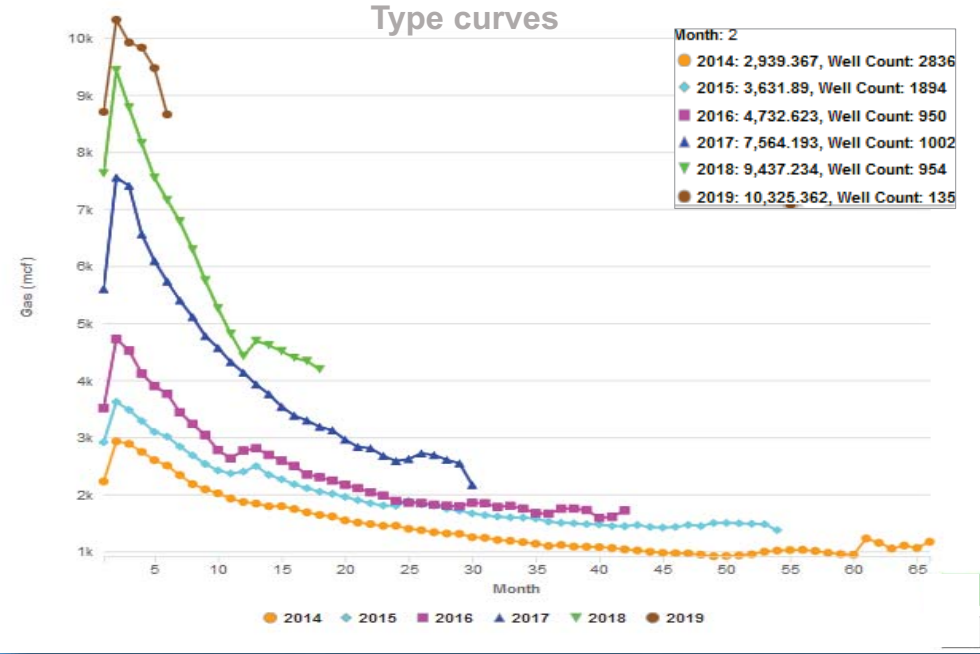
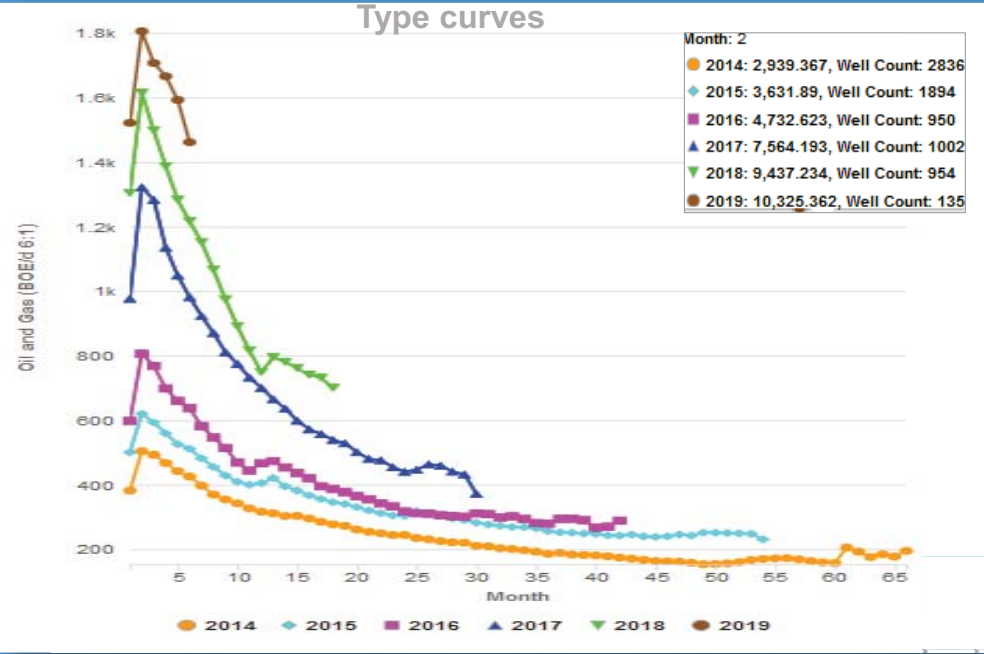
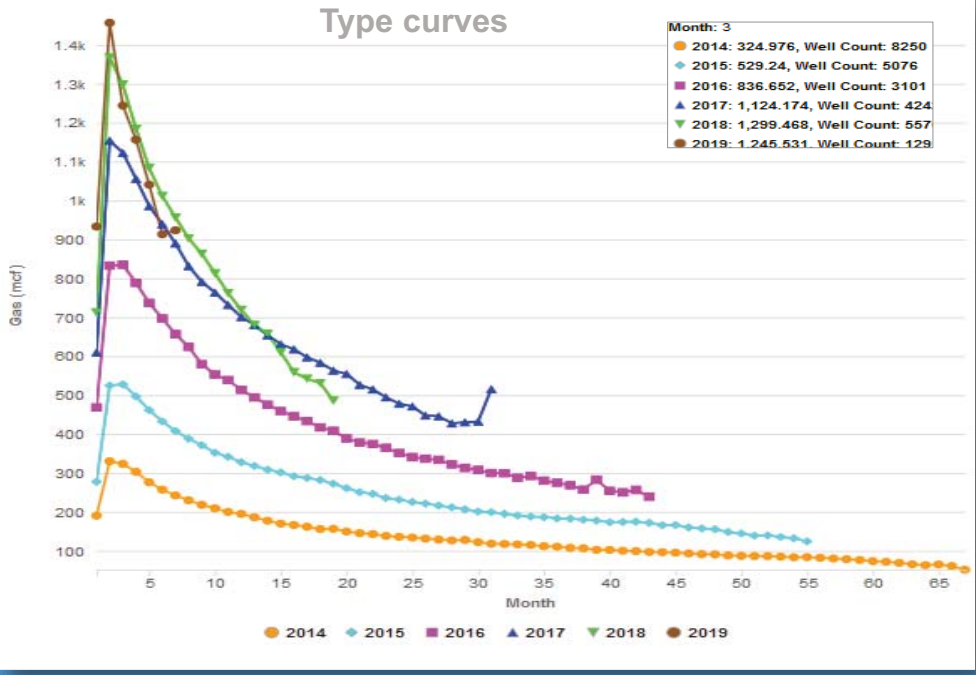
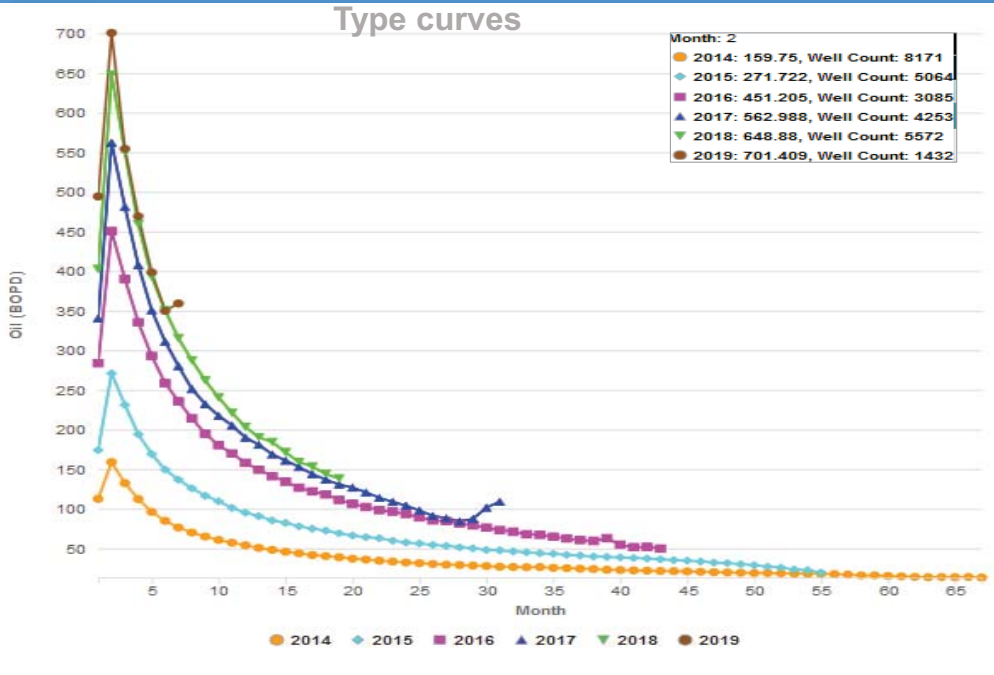
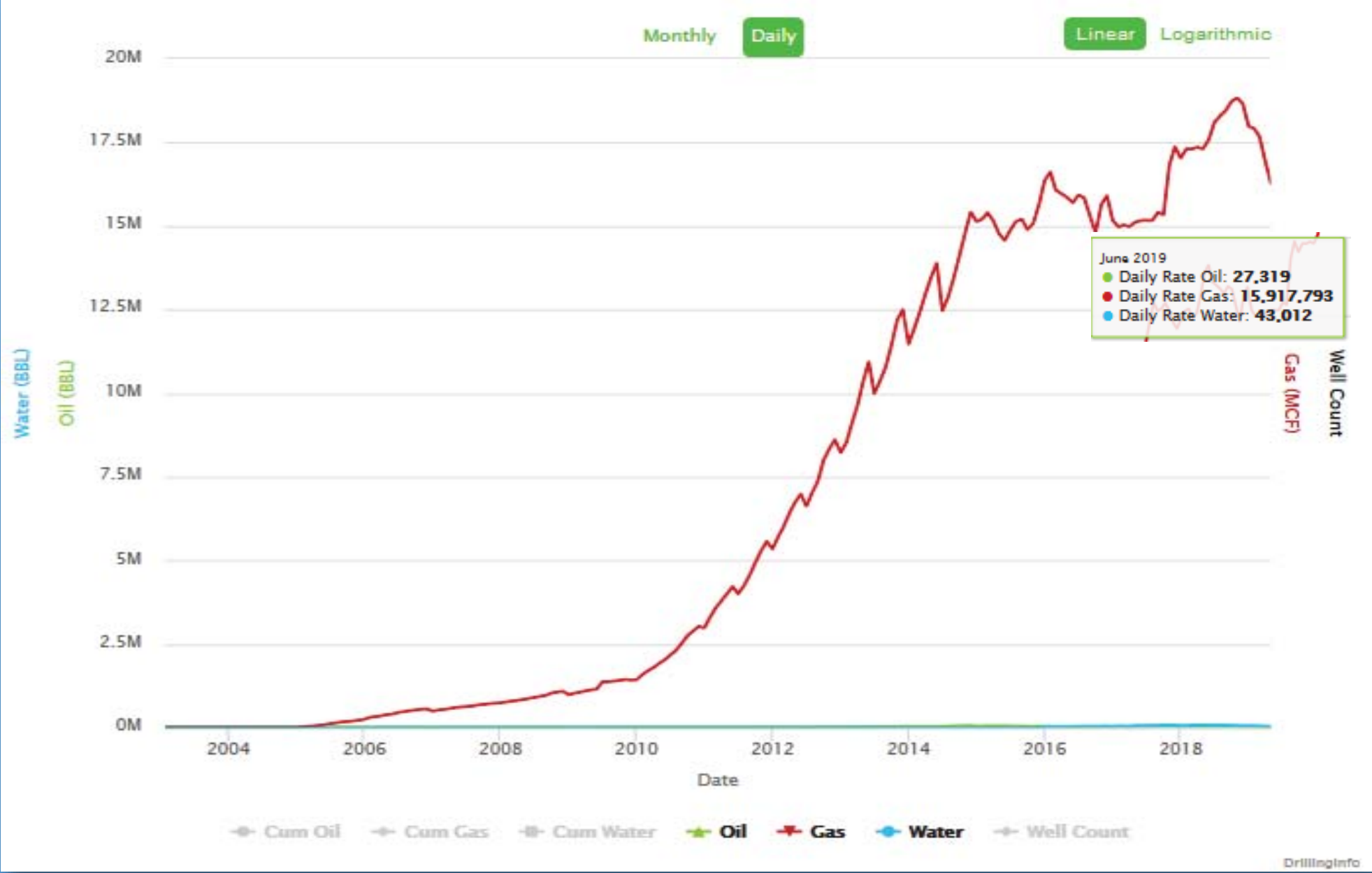
Utica Point Pleasant production January 2005 through June 2019



Permian Basin hydrocarbon production

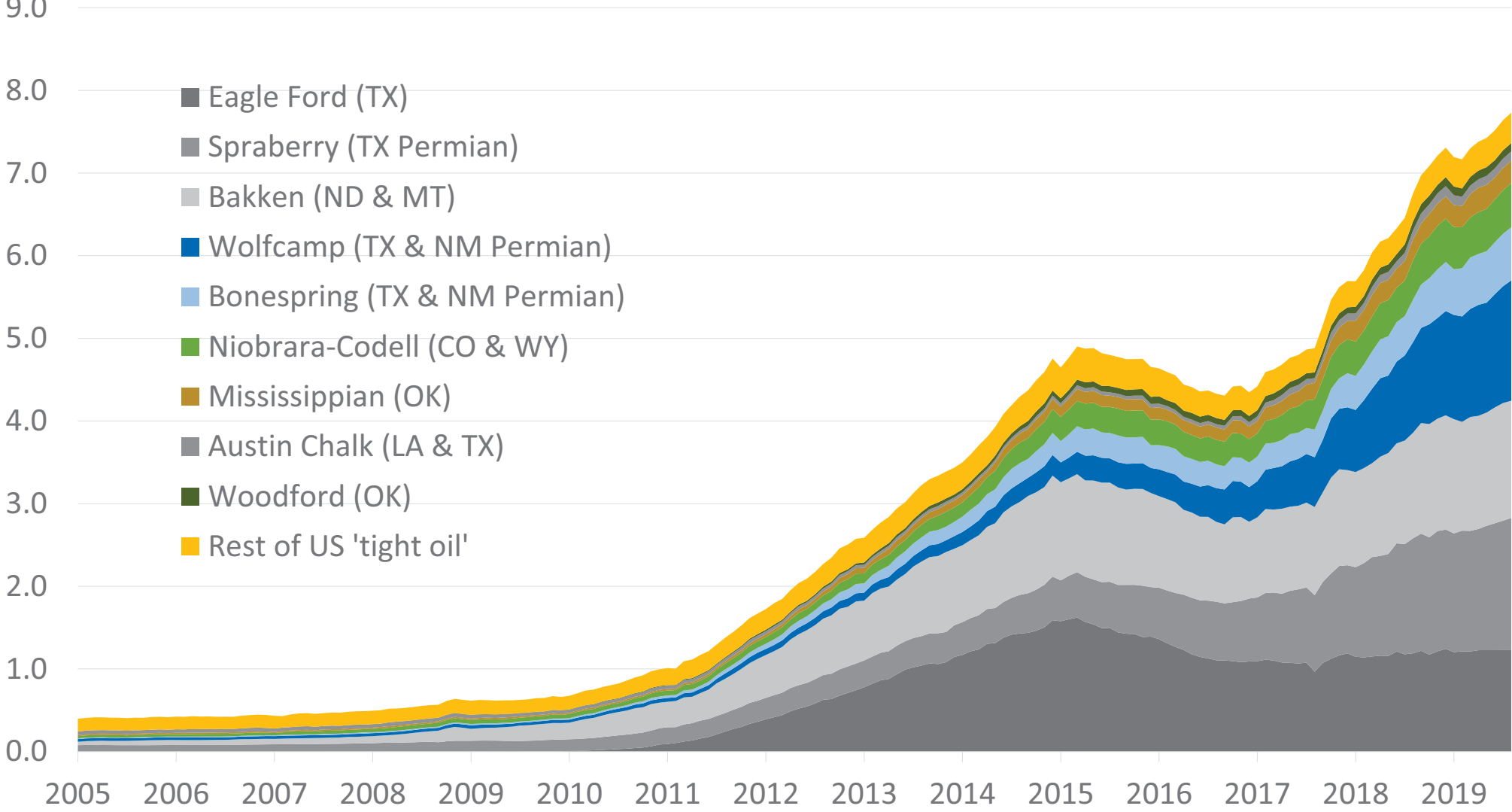


Appalachian Basin hydrocarbon production



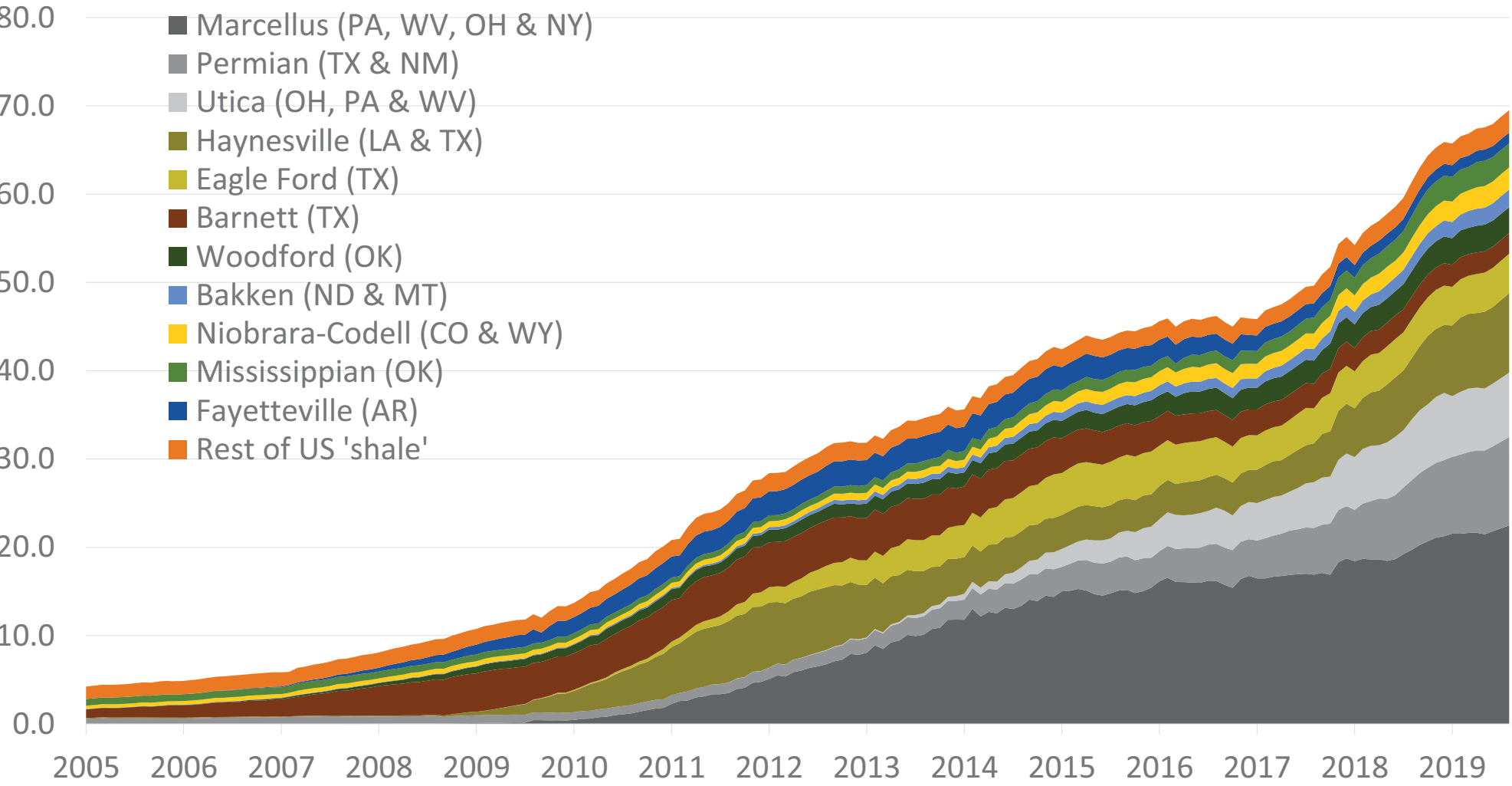
Monthly tight oil production – selected plays through August 2019

million barrels per day



Monthly dry shale natural gas production – selected plays through August 2019

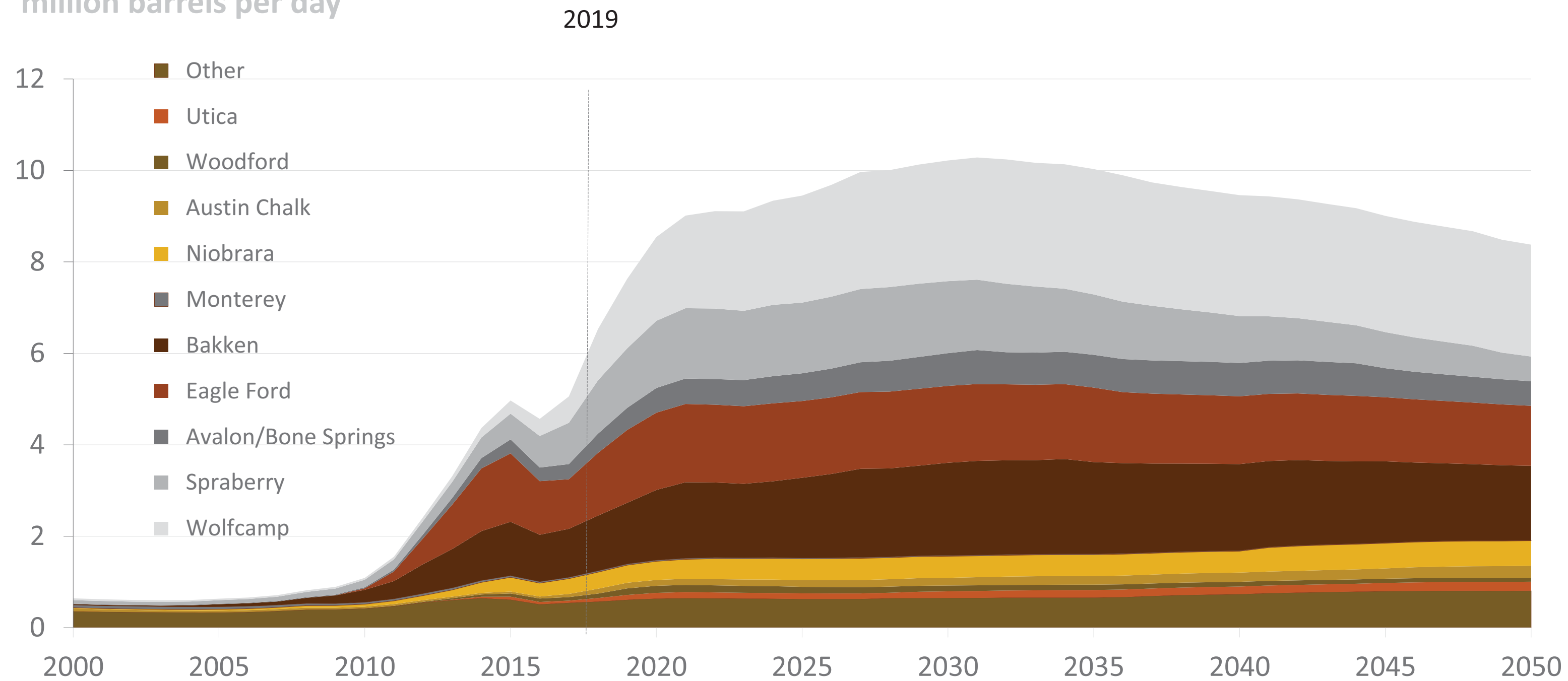
Billion cubic feet per day



U.S. tight oil production forecast through 2050

AEO reference case 2019

million barrels per day



U.S. Energy Mapping System:

www.eia.gov/special/shale/plays

EIA's maps web page:

www.eia.gov/maps/maps.htm#field

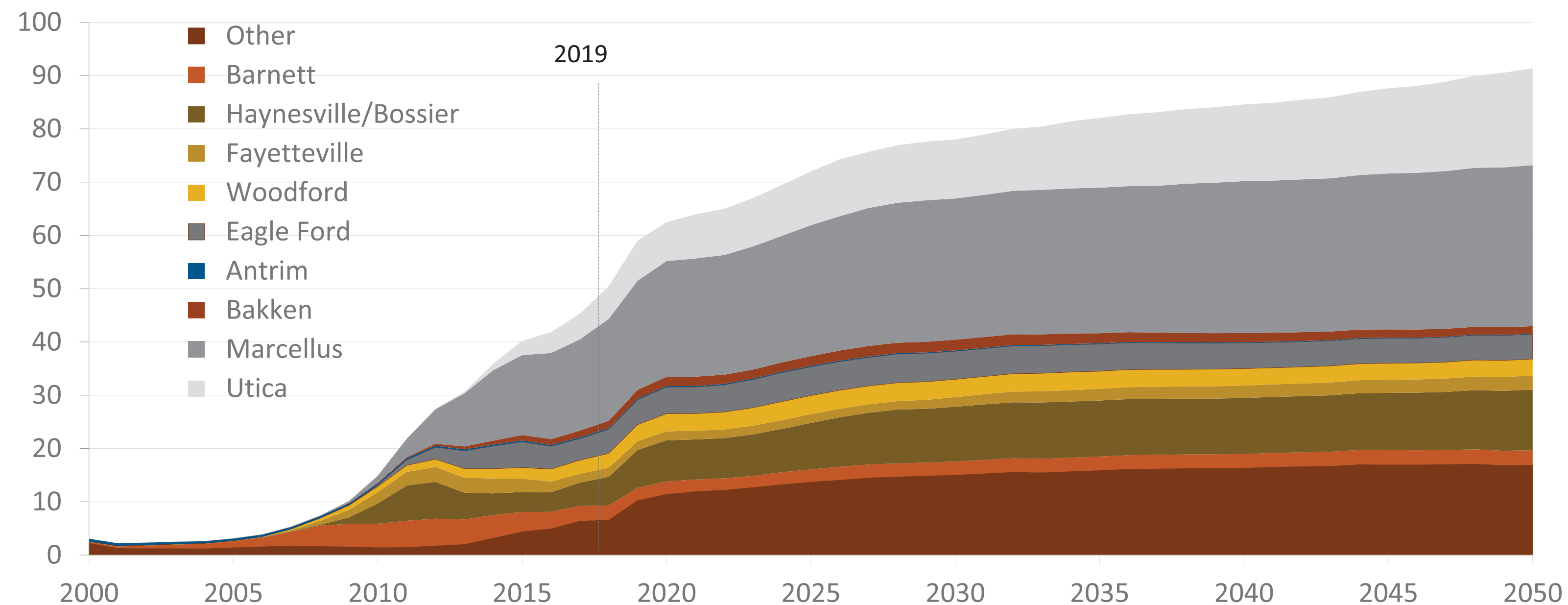
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U.S. shale dry natural gas production forecast through 2050

AEO reference case 2019

billion cubic feet per day



Acknowledgment:

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