Taking the Utica to its Depositional Limits: Through Facies Changes and Across the Entire Appalachian, Illinois and Michigan Basins*

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Abstract

Approximately 130,000 wells were digitized, interpreted and correlated using sequence stratigraphy to create a stratigraphic framework across the three basins of northeastern USA: Appalachian, Illinois and Michigan. From the stratigraphic framework it was determined that 13,000 digital wells logs (LAS) or 10% of the total digital wells penetrated the Trenton/Black River (the yellow well spots in Figure 1).

Detailed correlations were then added to the 13,000 LAS penetrating the Utica in order to visualize the Utica/Point Pleasant to its depositional limit or outcrop within northeastern USA. A visualization or pictorial representation of the Utica Shale is presented which will highlight relationships between the Utica play and the depositional system of approximately 450 million years ago. These relationships are displayed, understood and transmitted through concise graphic visualizations across the Appalachian, Illinois and Michigan basins.

Study Framework

Figure 2 is a cross section which begins in Tennessee and ends at the current Utica play in eastern Ohio. This cross section shows the surface to TD stratigraphic framework of the Appalachian Basin created and used to provide a frame of reference for play analysis of various target sequences ranging from the Utica to Marcellus, Mississippian and Upper Devonian organic shales and sandstone. The red well spots in Figure 2 represent the Utica wells drilled to date in the play (per IHS).

The procedure used to construct a digital stratigraphic framework of the Utica play was as follows.
A detailed digital stratigraphic framework of the underlying Trenton/Black River was constructed to bring a reliable set of chronostratigraphic correlations from below to identify the base of the Utica Shale. Detailed correlation of the Trentonian through the Chazyan was essential to linking the northeastern basins and was generally conducted within the window of 0-40 API gamma ray.

Figure 3 demonstrates the simplicity of pure, normalized LAS stratigraphy when the detailed correlations are turned off. Also note that all of the Utica and most of the Point Pleasant are invisible because most of the gamma ray values are greater than 40 API.

The gamma ray shale baseline of the Queenston/Reedsville Shale was meticulously normalized to allow a reliable set of micro-chronostratigraphic correlations above the Utica which would not have been possible with analog or raster well logs. Figure 4 again demonstrates that when correlations are not displayed, the normalized gamma ray (80-160 API) coalesces into the natural patterns of rock layers. Finally, a detailed digital stratigraphic framework of the Utica/Point Pleasant was then constructed based upon the normalized gamma ray LAS and density LAS.

Figure 5 shows two identical cross sections. The top cross section shows only the Utica, Point Pleasant and Trenton (base of Point Pleasant) markers in order to get an unobstructed view of the natural geology. The cross section on the bottom displays 12 detailed Utica/Point Pleasant markers. This detailed sequence stratigraphy of the play area illustrates that multiple Utica/Point Pleasant depositional layers should be individually mapped to their depositional limits.

Figure 5 also introduces the power of the color fill in visualizing high density cross sections. In Figure 5, the green color fill is used to emphasize API values greater than 150. This warm gamma ray of the Utica may indicate organic content. The red color fill emphasizes a low density window of values less than 2.65 G/cc. In many formations, low density is a direct indication of organic content.

The Utica/Point Pleasant correlations were then pushed into the Michigan and Illinois basins. Correlation of the Trenton/Black River across multiple basins was made possible through the display of the gamma ray window of 0-40 API. Also, in order to correlate the shallowest rock layers, through-casing, suppressed gamma ray was normalized to an open hole appearance.

As shown in Figure 6, once correlated, the Trenton/Black River brought a consistent datum that made it possible to navigate around the central Tennessee and central Kentucky structures; note the Utica outcropping in the center of the Illinois to Ohio cross section.

Results and Interpretation

Using 13,000 digitized, normalized and correlated Utica/Point Pleasant wells across the areal extent of the entire northeast makes possible the mapping and analytical analysis of the extended play. For example, a gross isopach of the Point Pleasant is shown in Figure 7. From this map, it becomes apparent that a gently arching trend of thin Point Pleasant (less than 100 feet) exists from Tennessee to New York. This trend could be caused by a paleo structural high which enhanced Trenton reef development to the western side. An extremely thick deposition (over 300 feet) of Point Pleasant also exists in eastern Tennessee and Kentucky.

An analytical process of creating a net clean gamma ray isopach (less than 50 API) was conducted and is shown in Figure 8. This net clean gamma ray isopach shows a very distinct Point Pleasant reef west of the possible paleo high. At a 50 API cutoff, eastern Tennessee and eastern Kentucky is the location of thick, low API sediment, indicating a possible sediment contribution from the Tennessee/North Carolina area.

Gamma ray API cutoffs of 50, 30 and 15 were run to illustrate the facies change from the eastern Tennessee and Kentucky clean API feature to the northeast into the Utica play. Note the effect of the uplifts in central Tennessee and central Kentucky on the net clean gamma ray isopach. The complete Point Pleasant depositional system across the large areal expanse of the northeastern USA is shown in Figure 8.

Conclusions

Viewing plays within their regional context and with high definition resolution is only made possible through the use of a digital geologic database of LAS and sequence stratigraphy. This combination of analytical and interpretive digital data on a massive scale allows visualization of features and trends never before envisioned.

On the other hand, visualization of the Utica/Point Pleasant system emphasizes the extensive amount of geologic, petrophysical, geochemical and reservoir engineering still required in order to map the individual reservoirs and determine the play's sweet spots. For example, as shown in the cross section in Figure 8, there are several obvious layers of low density values indicating organic content which should be mapped individually following the meticulous normalization of all density logs. Once all available data points from each of these disciplines is inserted into the detailed stratigraphic model of the Utica/Point Pleasant, each individual time slice can then be mapped as its own depositional system to identify the organic distribution, types of hydrocarbons and sweetest spots of the play.

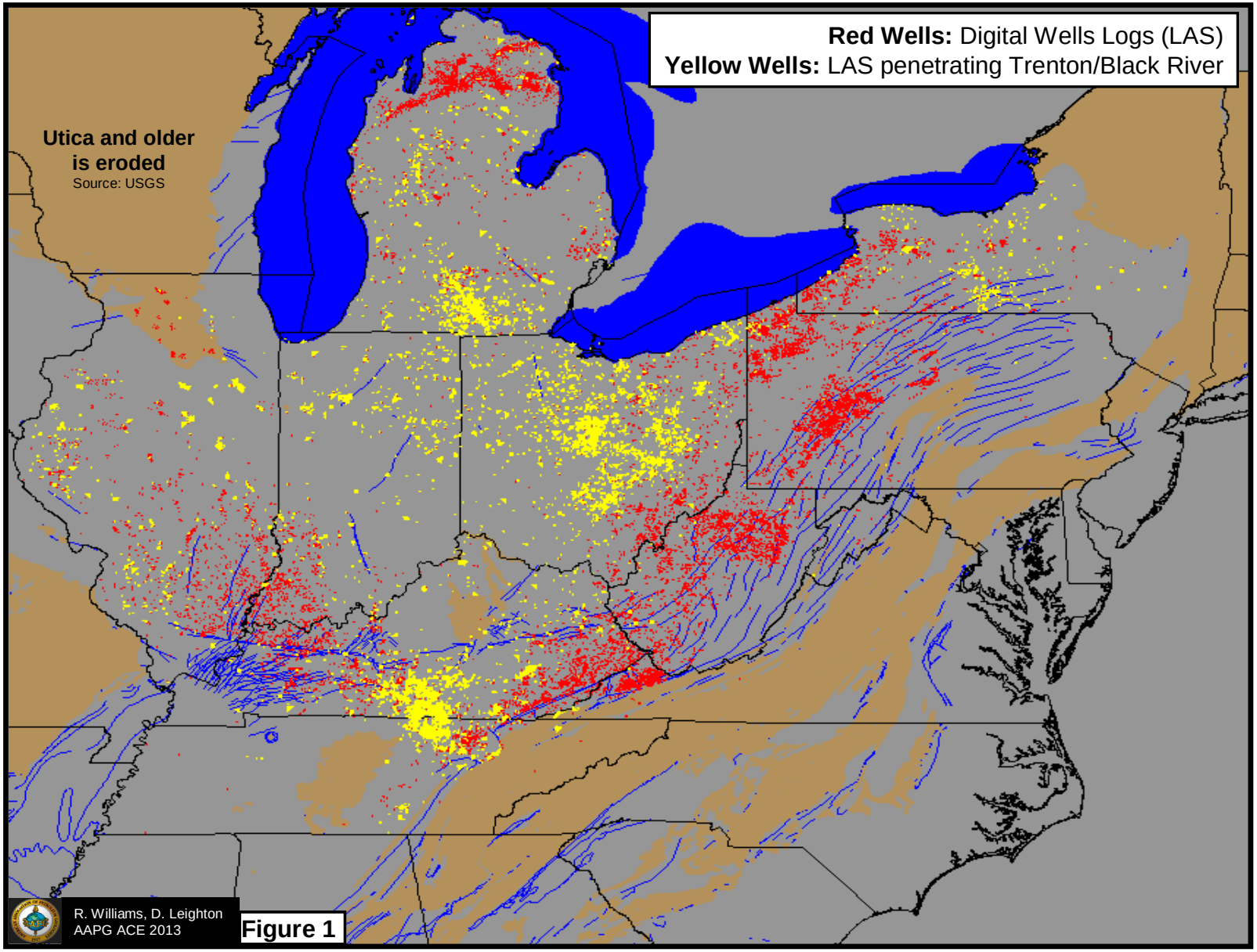


Figure 1. Of 130,000 wells (red well spots) in the Appalachian, Illinois and Michigan basins, 13,000 digital well logs (LAS), or 10% of the total digital wells, penetrated the Trenton/Black River (yellow well spots).

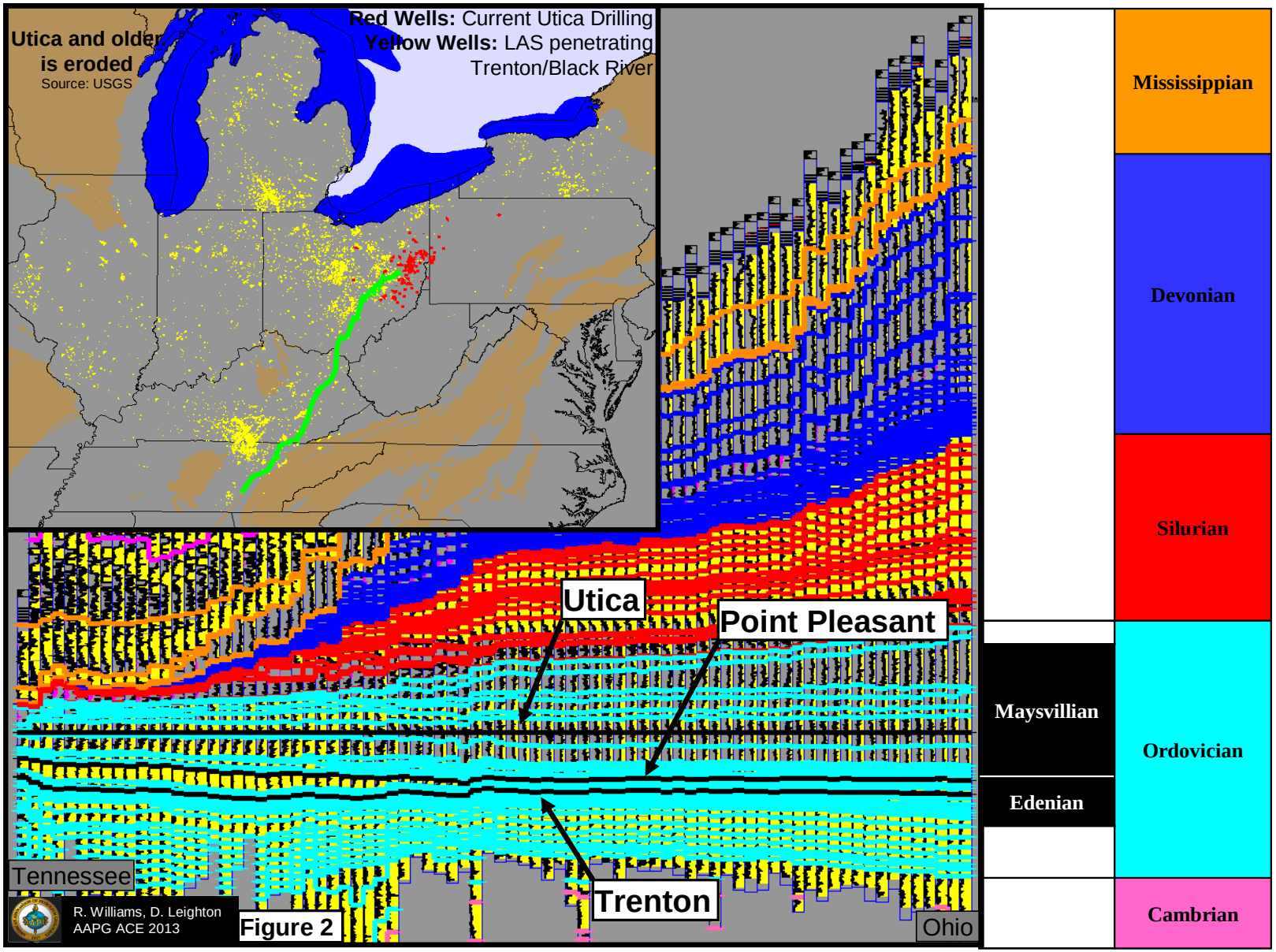


Figure 2. Cross section which begins in Tennessee and ends at the current Utica play in eastern Ohio.

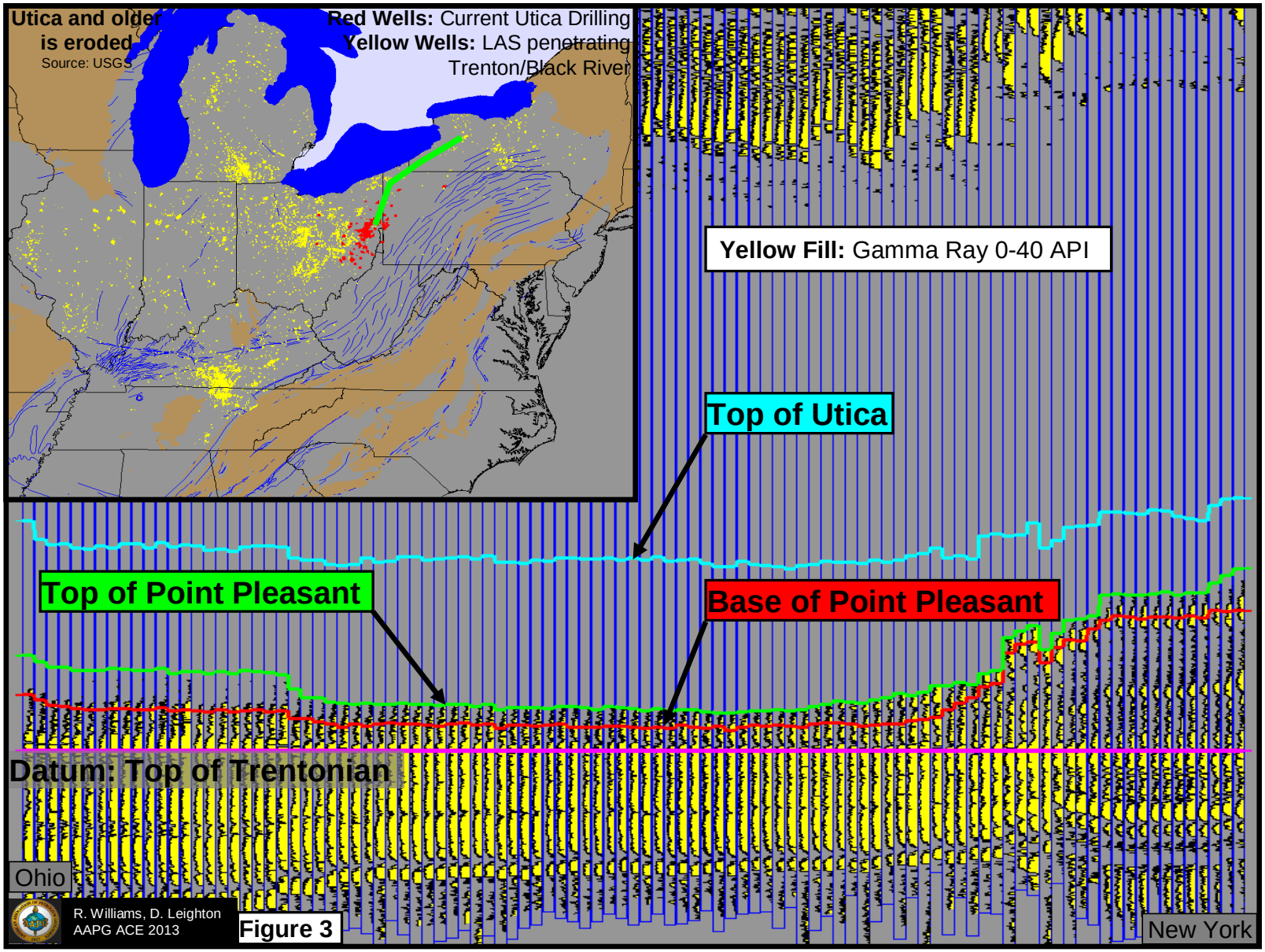


Figure 3. Cross section demonstrating the simplicity of pure, normalized LAS stratigraphy when the detailed correlations are turned off. Also note that all of the Utica and most of the Point Pleasant are invisible because most of the gamma ray values are greater than 40 API.

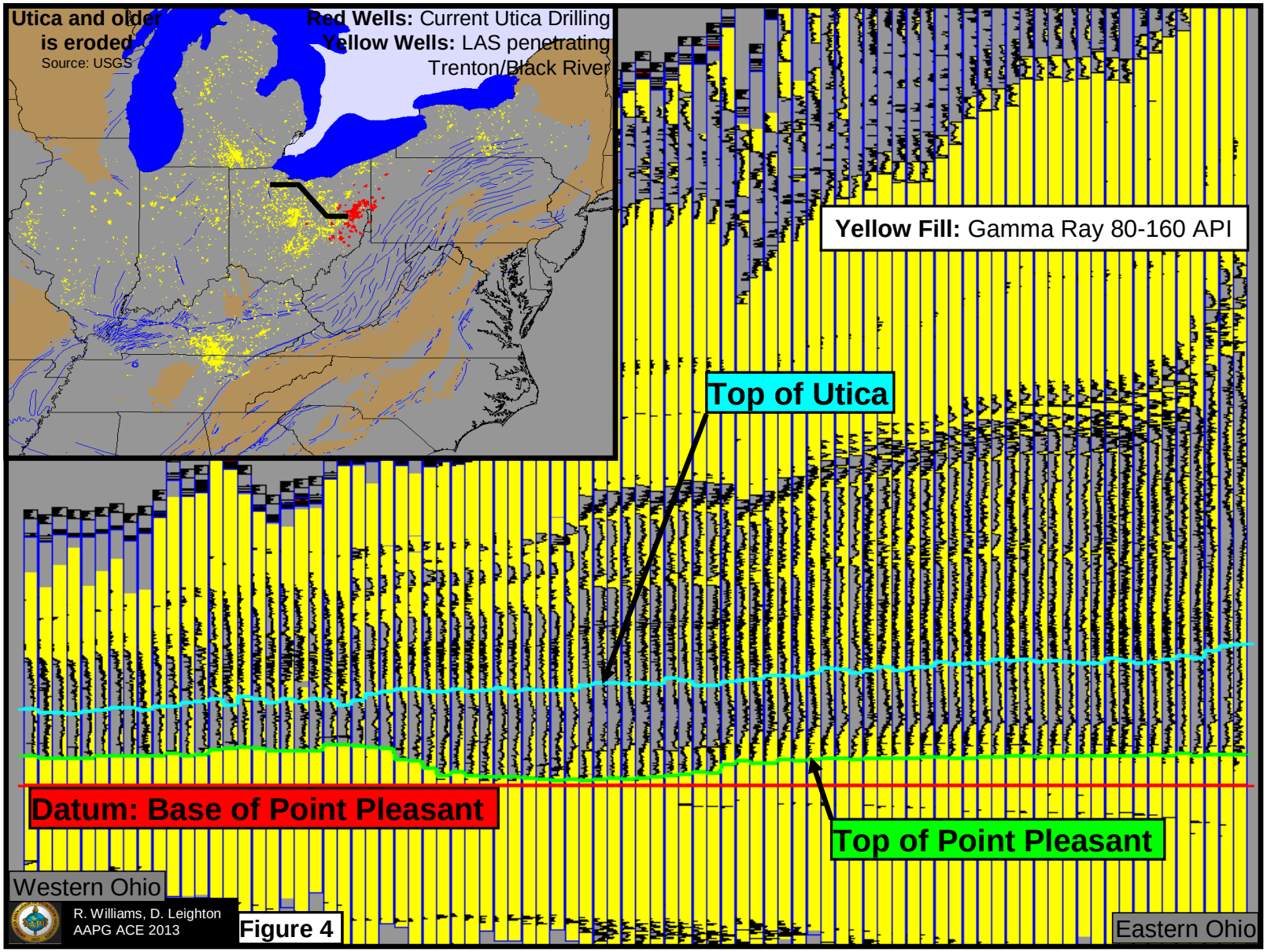
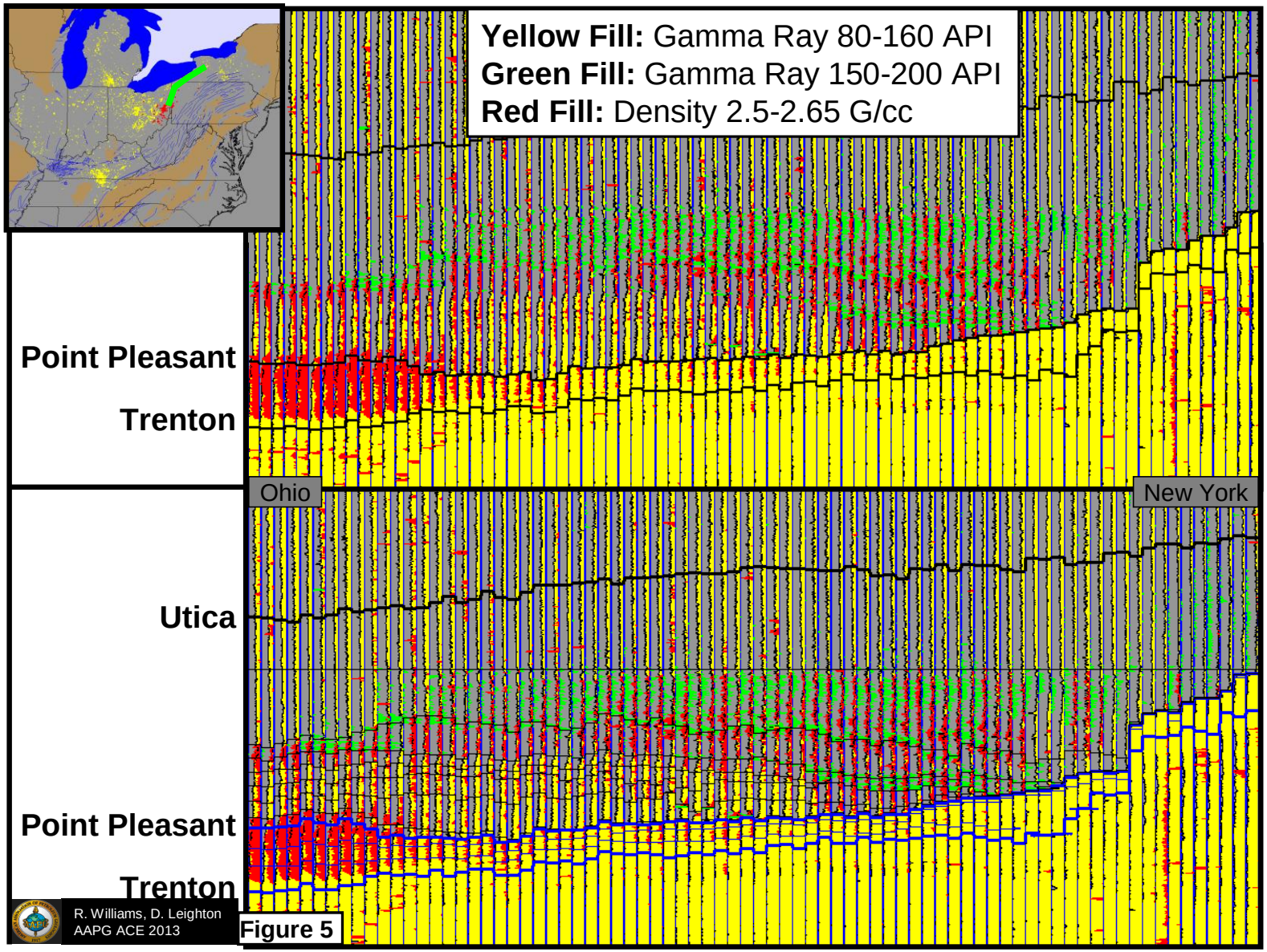


Figure 4. Again demonstrates that when correlations are not displayed, the normalized gamma ray (80-160 API) coalesces into the natural patterns of rock layers.



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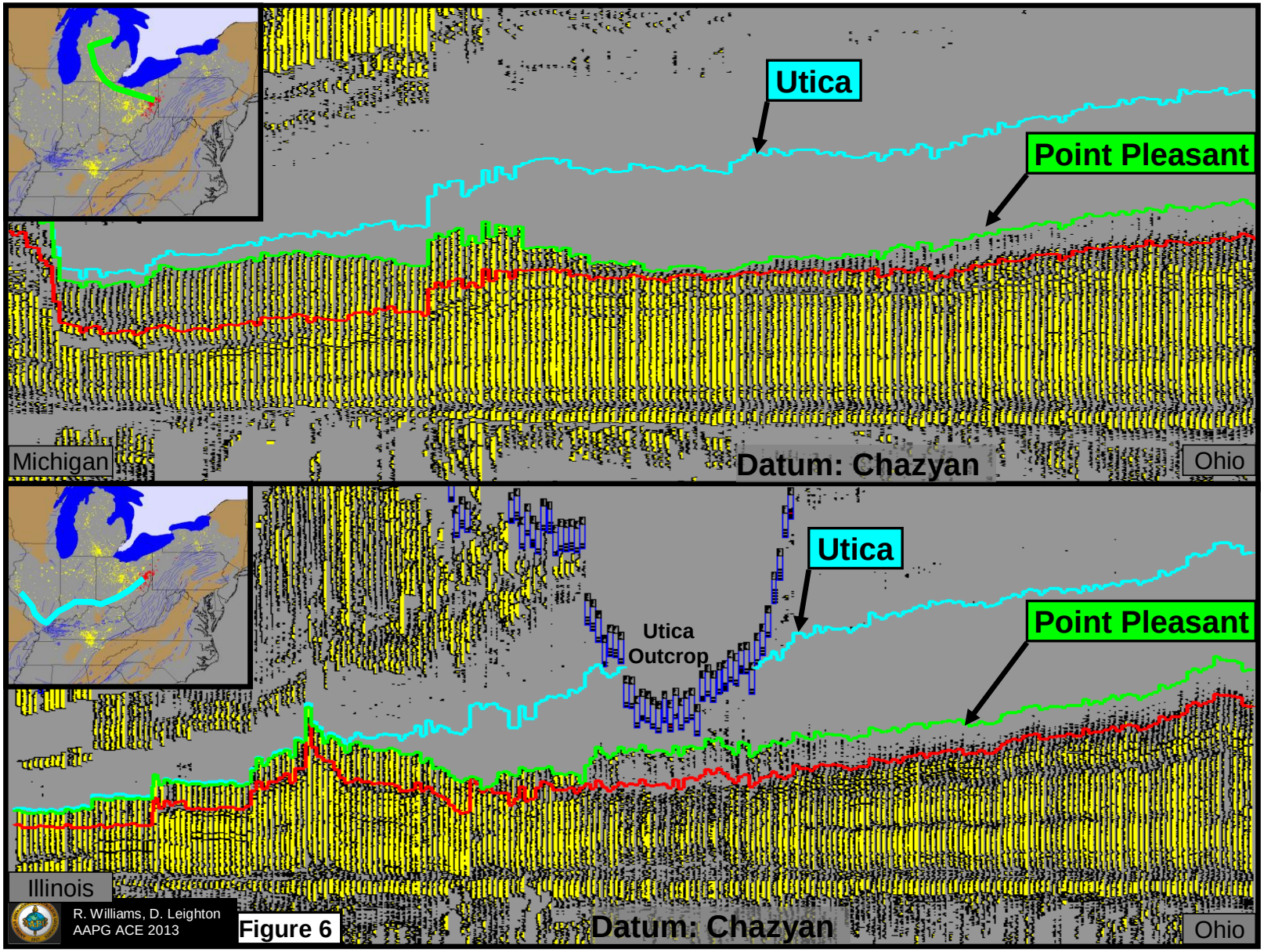

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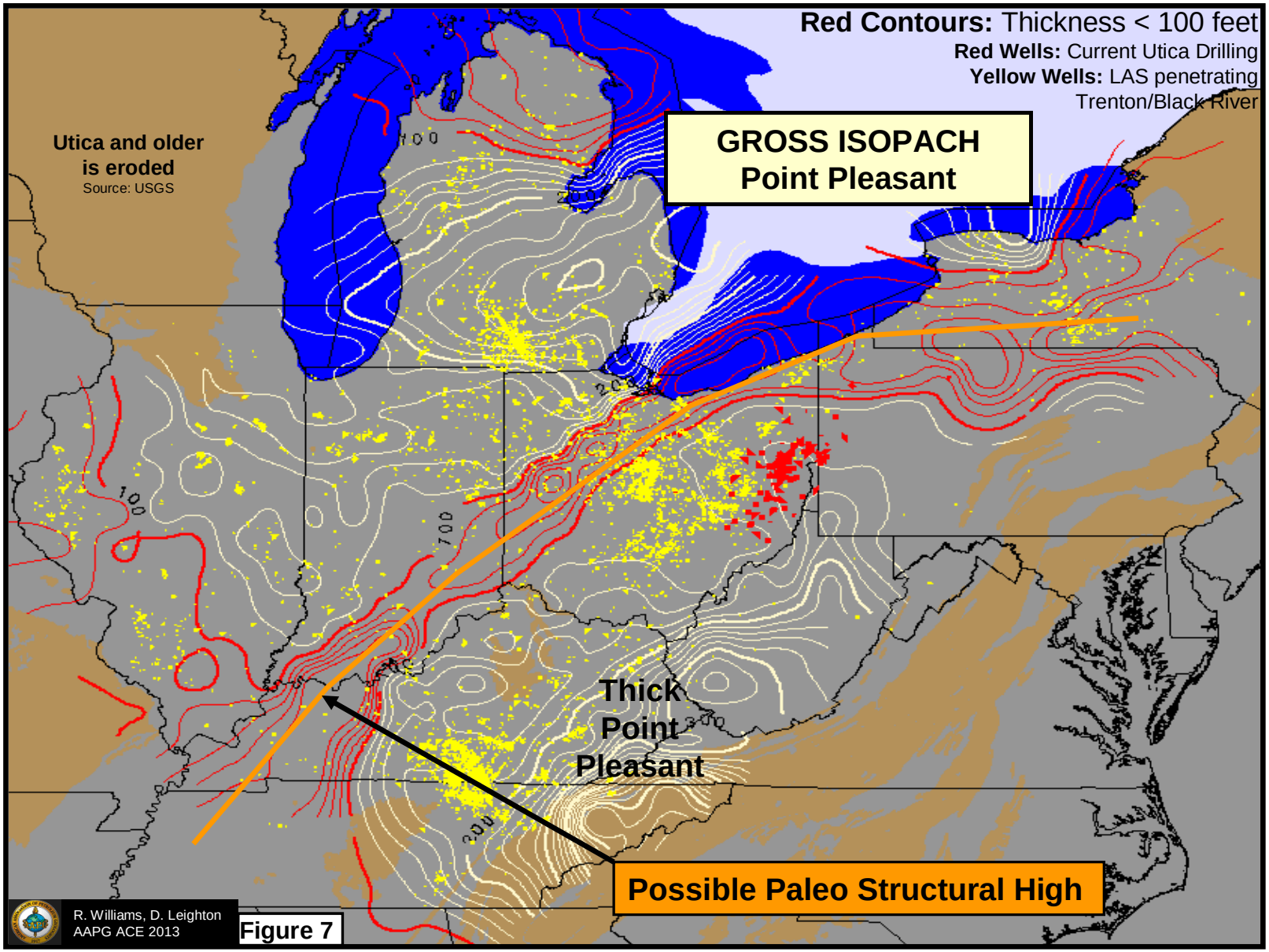

Figure 7. Gross isopach of the Point Pleasant.

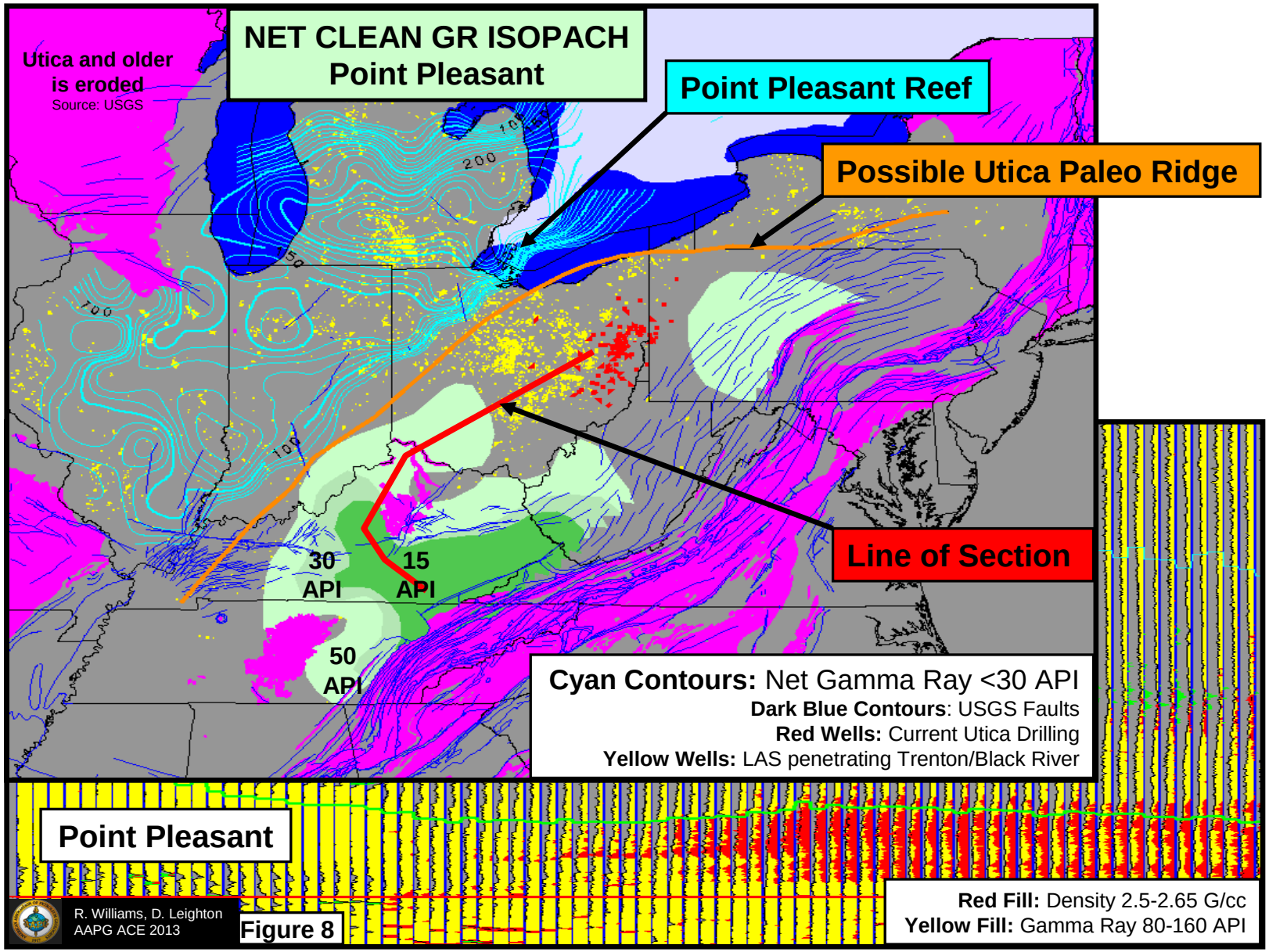

Figure 8. The complete Point Pleasant depositional system across the large areal expanse of the northeastern USA, including net clean gamma ray isopach (less than 50 API) of Point Pleasant.