Identifying new drilling areas in Midland basin integrating latest GIS buffering technology and geological mapping.

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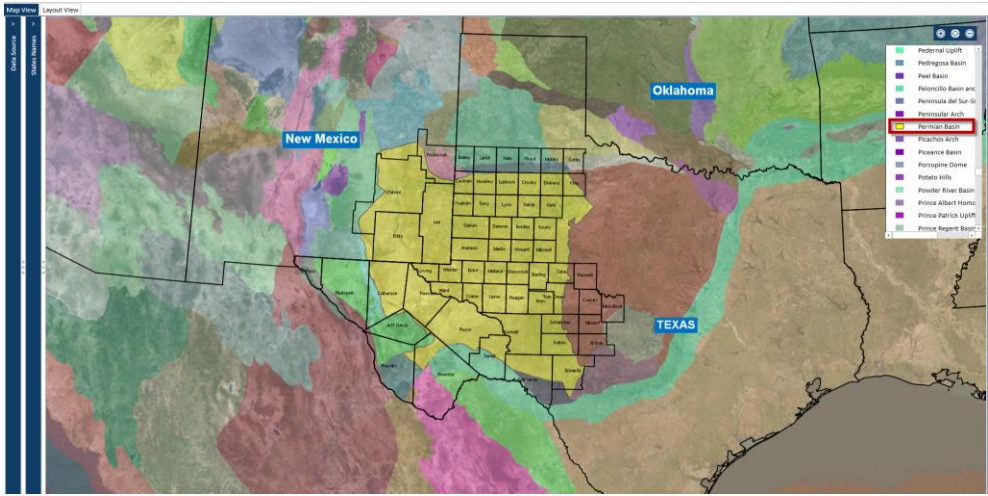
Introduction

- The Permian basin has been producing oil and gas for almost a century. It is so bounteous that it fueled the Allied forces battling Germany and Japan during World War II.

- As it is expected, the basin started to declined, but technological advances in unconventional reservoirs push back the Permian basin in to the game and it is now one of the most generous in the world. In 2012, horizontal well development began to surpass vertical well development, accelerating year over year. Today vertical wells comprise only 5% of the play while 8,000-10,000 ft horizontal wells dominate the rest.



- With about one million wells, the basin provides enough information that can be analyzed with different disciplines to find drilling areas. Due to the high density of wells and state regulations, it is necessary to include GIS techniques along with geoscience and engineering studies to find the next sweet spot area.

- This presentation will demonstrate an approach of how to combine advances in GIS buffering technology with common practices in the oil and gas industry to accomplish the proposed goal, and the methodology will be highlighted using a case study from one of the Wolfcamp benches (B Upper) in the Midland basin.

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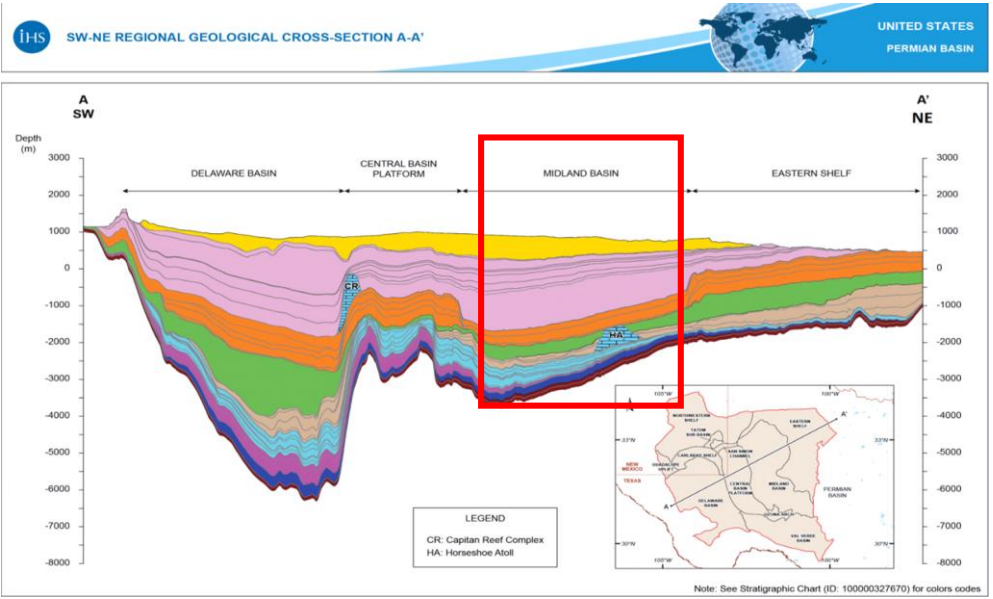
Midland Basin Location



- The Permian Basin is a foreland basin divided into two main subbasins: the steeply dipping Delaware Basin to the west and the shallow-dipping Midland Basin to the east.
- The Permian-age Wolfcamp Formation exists throughout the Delaware and Midland basins; therefore, the term applied herein, Wolfcamp Midland, applies only to the Wolfcamp section that exists throughout the Midland Basin.
- The Wolfcamp Midland play is one of the recent major Permian Basin "stacked pay" plays that continues to grow despite persistently low oil prices. One of the most widely used terms in industry today to describe the appeal of the Permian Basin, the phrase "stacked pay" refers to multiple benches, or target intervals, that are relatively close stratigraphically. The Wolfcamp Midland play consists of six major benches within the Wolfcamp and Spraberry formations, many of which are widespread across the Midland Basin core

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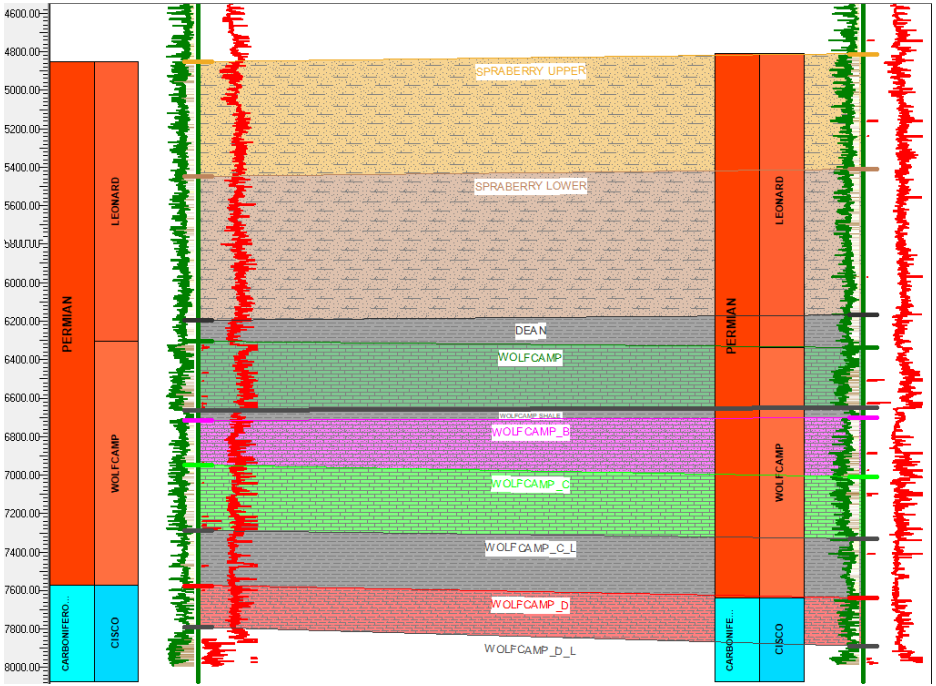
Stratigraphy

- The Wolfcamp Formation is composed of predominantly organic-rich shales, interbedded with carbonate debrites, and clastic turbidites with porosities of 4 to 10%. Organic-rich shale intervals contain total organic carbon (TOC) contents of 2.0-8.8%. The formation is in the oil window with a vitrinite reflectance (%Ro) of 0.85-0.9%.
- IHS Markit has defined five members that comprise the Wolfcamp Formation: Wolfcamp A-D and the Wolfcamp Shale. Wolfcamp A is so far the best producer bench, but some companies are starting to focus on Wolfcamp B, which is producing in average between 60 to 70 boe/d per 1000 ft lateral feet. The focus of this presentation will be Wolfcamp B.



- The Wolfcamp Formation has an average gross thickness of 300-600 ft in the north and up to 2,000 ft in the south. It is found at varying depths across the basin, most commonly at 4,500-9,500 ft (total vertical depth [TVD]) in producing zones. (***Droege L, & Olmestead R, IHS Markit, 2017***).

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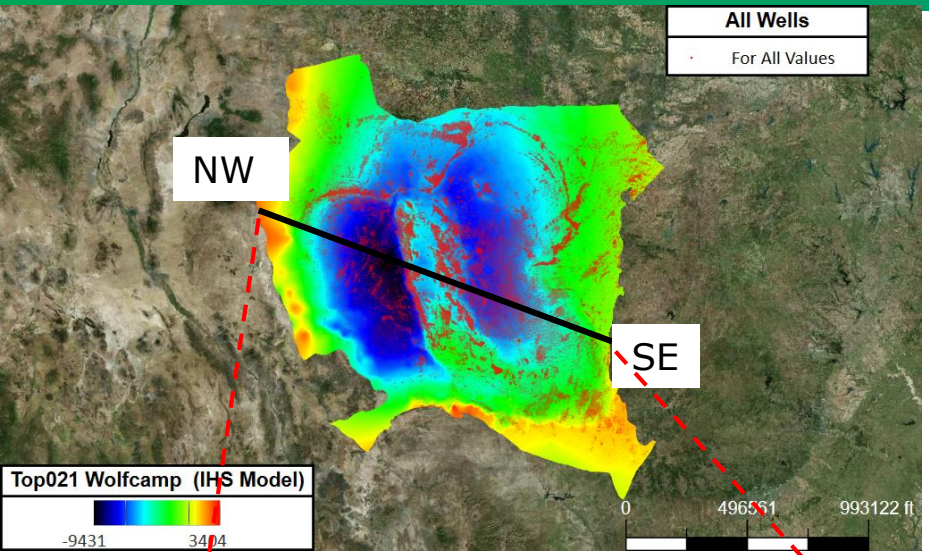
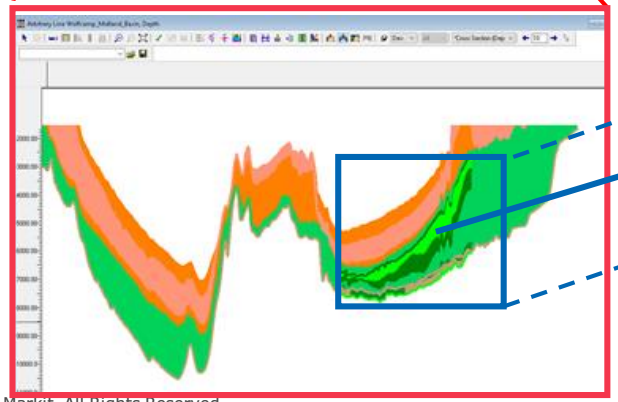
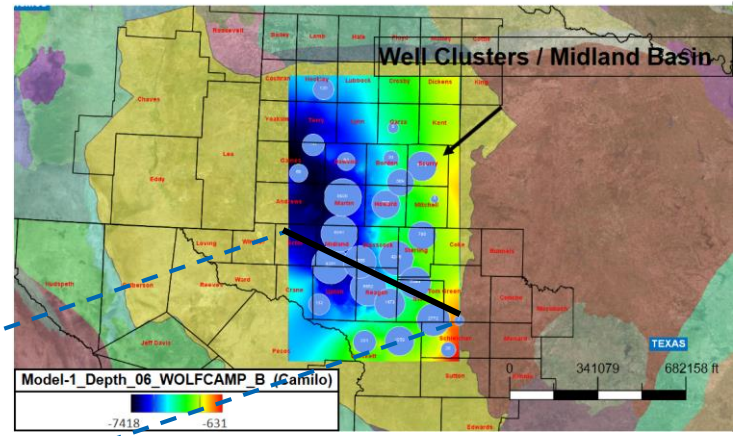
Structure Map Wolfcamp Formation – Permian Basin





Wolfcamp B



Structure Map Wolfcamp B Formation (Case study) - Midland Basin

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Structural Mapping in the Midland Basin – Highlighted with ESRI Technology

In the Midland Basin, IHS Markit currently has 23427 wells interpreted for the Wolfcamp formation. The other benches are interpreted with much less wells. Wolfcamp B, for example is interpreted in 2130 wells for the same area. Advance mapping techniques with geological rules is necessary to properly model the Wolfcamp B structure.

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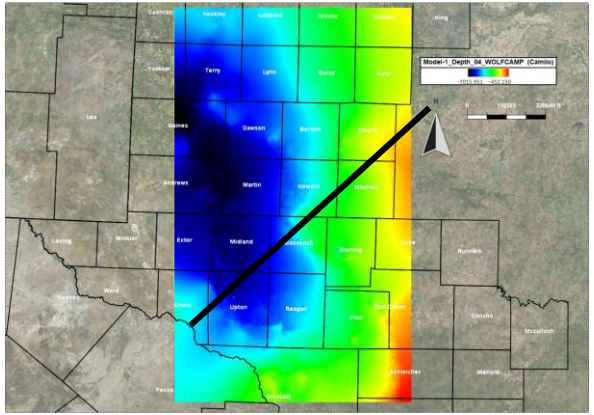
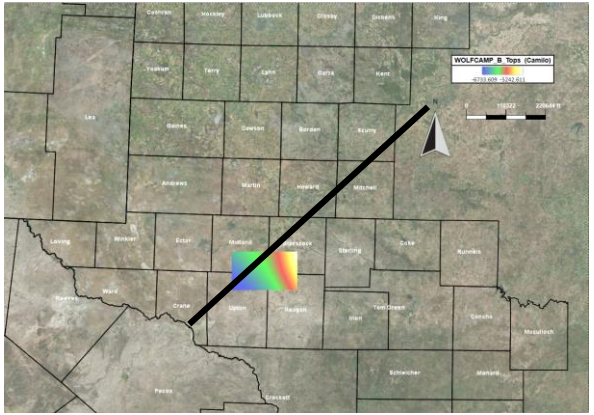
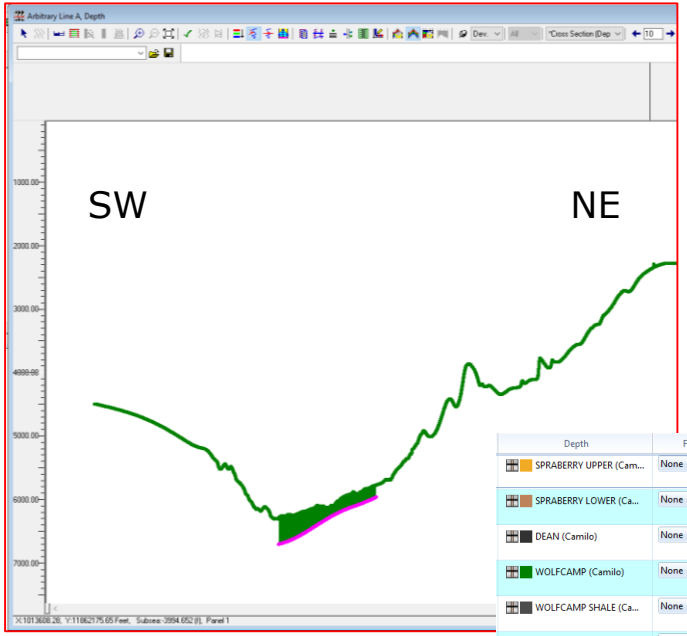
Defining Wolfcamp B Structure and Thickness

Structure Map - Top Wolfcamp Formation based on 23427 wells



Structure Map - Top Wolfcamp B based on 2130 wells





Depth	Fault Polygon	Framework Rules
SPRABERRY UPPER (Cam...	None	Non-Conformable
SPRABERRY LOWER (Ca...	None	Conform to surface above
DEAN (Camilo)	None	Conform to surface above
WOLFCAMP (Camilo)	None	Conform to surface above
WOLFCAMP SHALE (Ca...	None	Conform to surface above
WOLFCAMP_B (Camilo)	None	Conform to surface above
WOLFCAMP_C (Camilo)	None	Conform to surface above
WOLFCAMP_C_L (Camilo)	None	Conform to surface above
WOLFCAMP_D (Camilo)	None	Conform to surface above
WOLFCAMP_D_L (Camilo)	None	Conform to surface above
No items selected.	None	Conform to surface above

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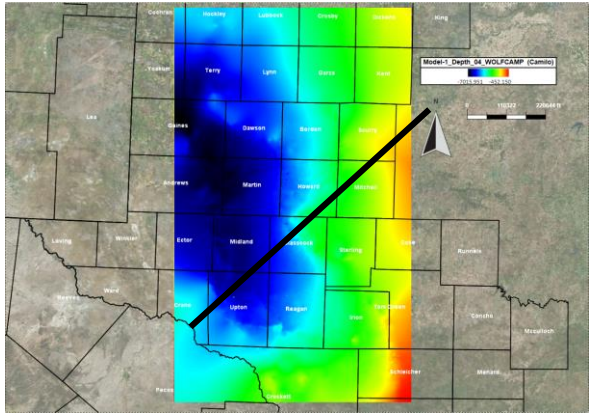
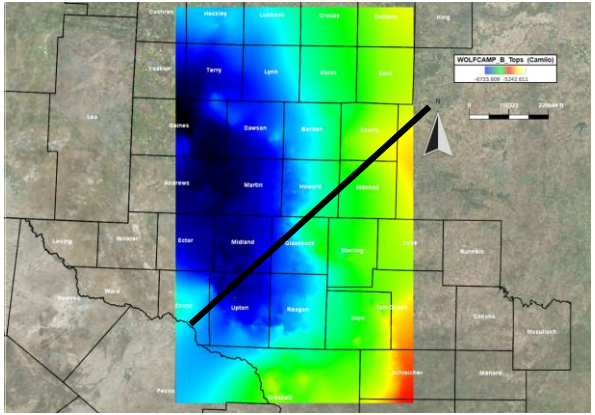
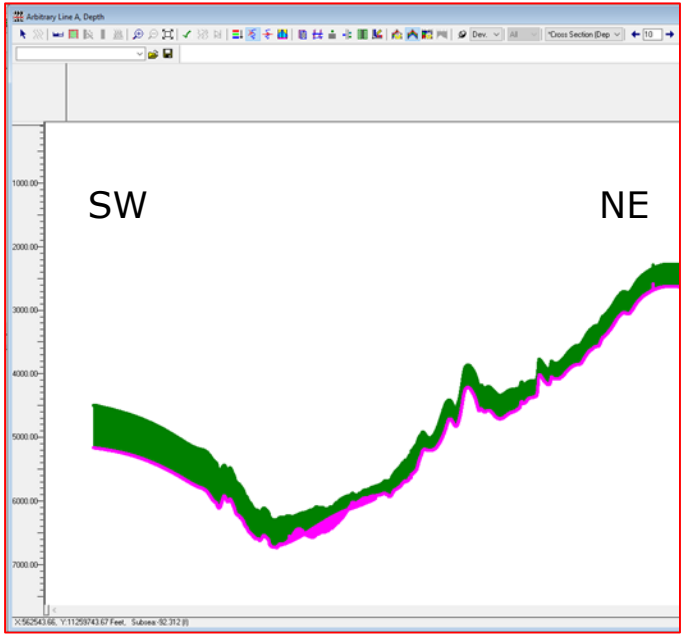
Defining Wolfcamp B Structure and Thickness

Structure Map - Top Wolfcamp Formation based on 23427 wells



Structure Map - Top Wolfcamp B based on 2130 wells





Structure Map and cross section profile. Top Wolfcamp B after applying conformable geological rules

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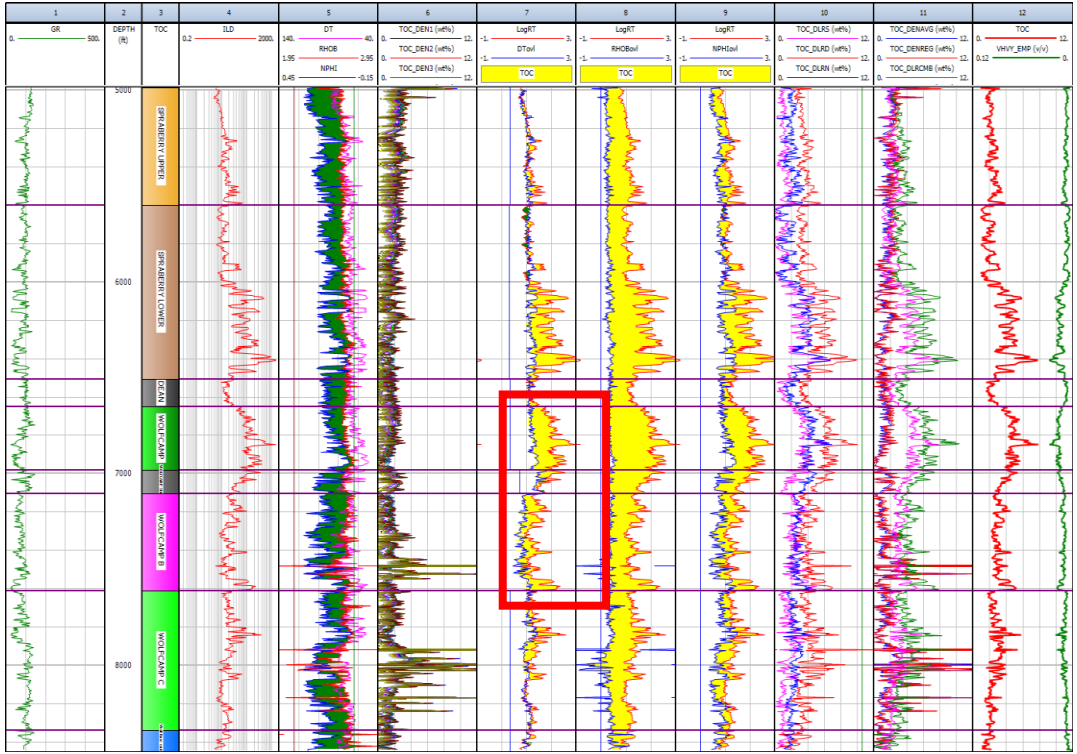
Defining Wolfcamp B Petrophysical Properties – Total Organic Carbon Content



- Most of the wells in the study area have GR logs, those logs were properly normalized and then used for clay volume calculations and to identify the zones to calibrate Sonic and Resistivity logs for TOC calculation per Passey's methodology. (**Passey, et. al., 1994**)
- For TOC calculations, the sonic log and resistivity logs were calibrated in water saturated organic rocks (Upper part Spraberry lower formation)
- After the calibration, Sonic log and resistivity log separate from each other in Wolfcamp A and B benches due to the presence of low density/low velocity kerogen and the presence of fluids, more likely hydrocarbons.

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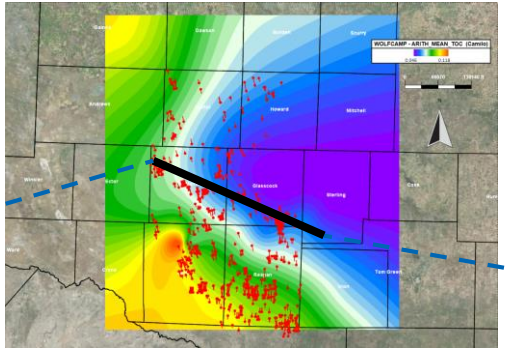
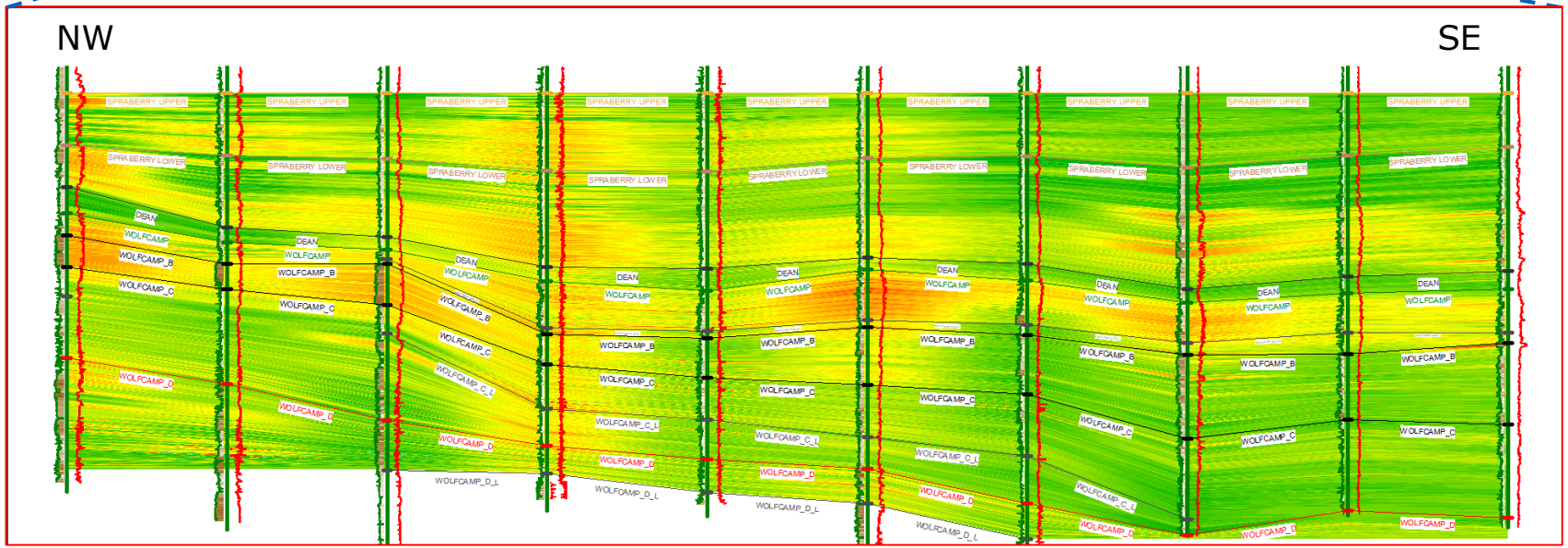
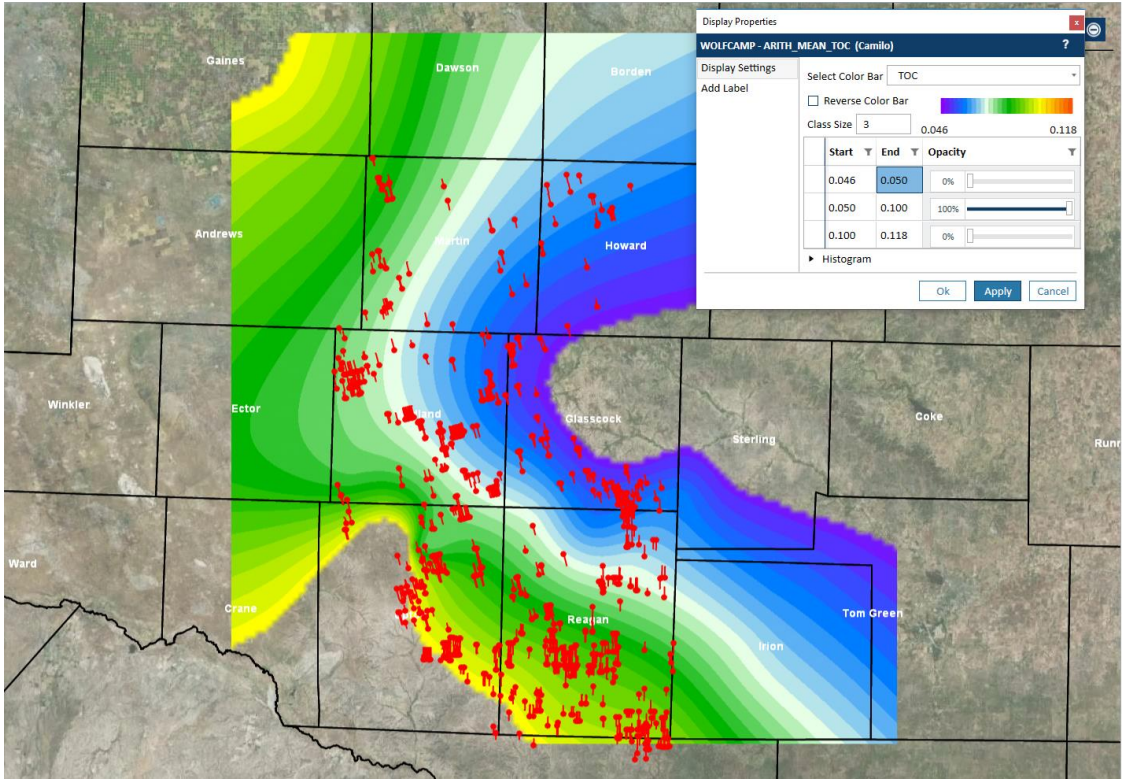
Wolfcamp B Upper TOC Map



- In the type log and in the cross section, one can see that the best TOC distribution happens at Wolfcamp A bench. This is why it is the most prolific and exploited bench. Wolfcamp B shows important TOC accumulations and it has also been proved to be profitable.



Wolfcamp B TOC Map with opacity control



- Detailed opacity control, technology that traditionally was exclusively used by geophysicists for 3D seismic volume interpretation, has been incorporated in ESRI based mapping system to better highlight the relevant values in the map and thus help finding better spatial data relationships.
- In this map, one can see in red all the Oil producing wells from Wolfcamp B bench. In the TOC map we have applied opacity control to hide to lowest TOC values. Notice that the distribution of the producing wells follows a TOC pattern. This picture shows that the productive TOC percentage in Wolfcamp B is between 5% and 9%.

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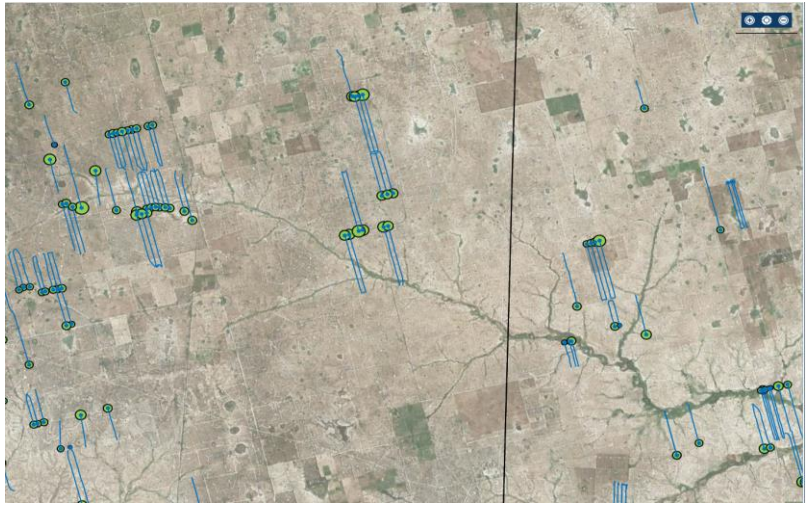
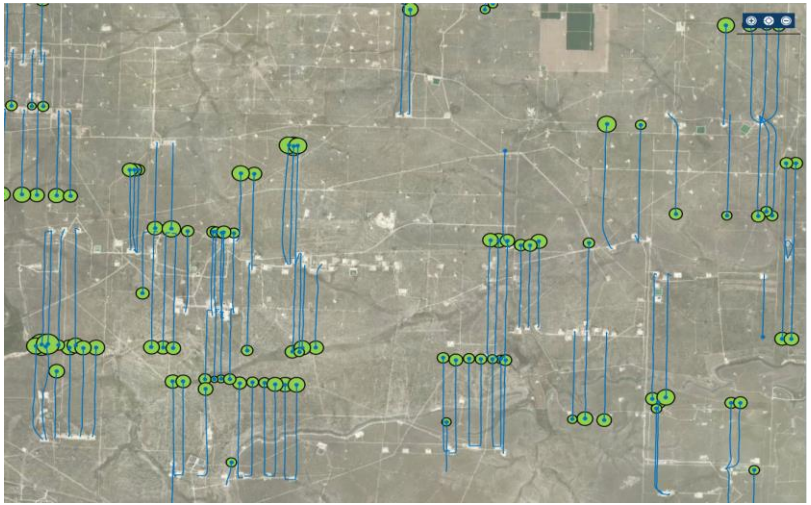
But, what's is controlling production in Wolfcamp B?



Production variability Midland County



Production variability Reagan County

Geological properties seem to match the producing wells, but why do we have a lot of variability in wells that are close by and in the same geological area with apparent same properties? Next we have to include in the analysis engineering data, understand how the wells are being completed, and create a production prediction map assuming equal conditions for all the wells.

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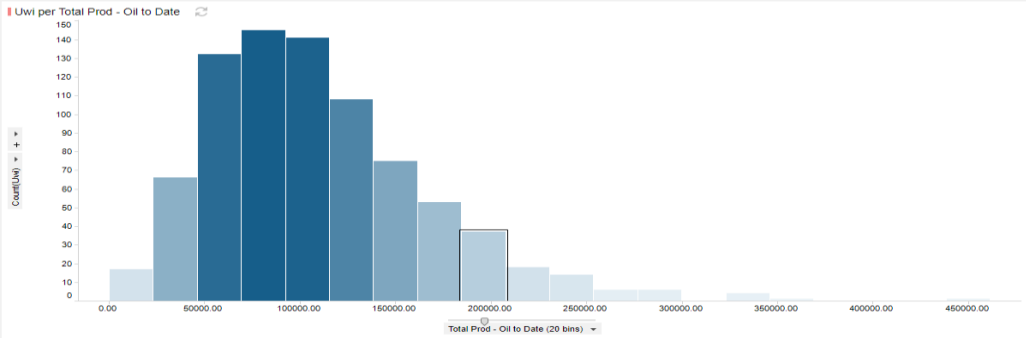

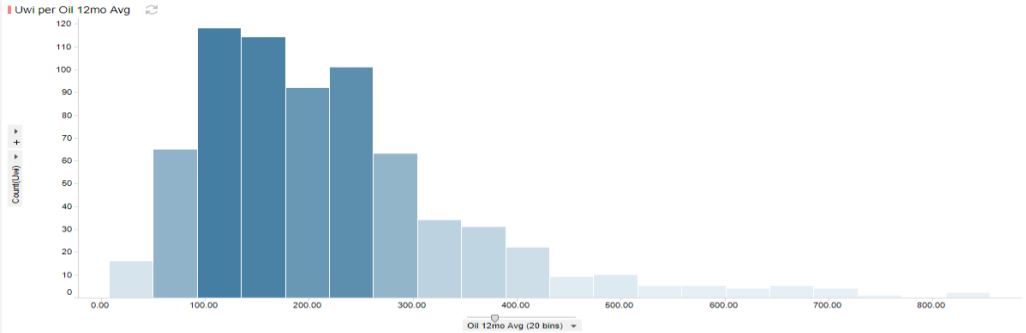

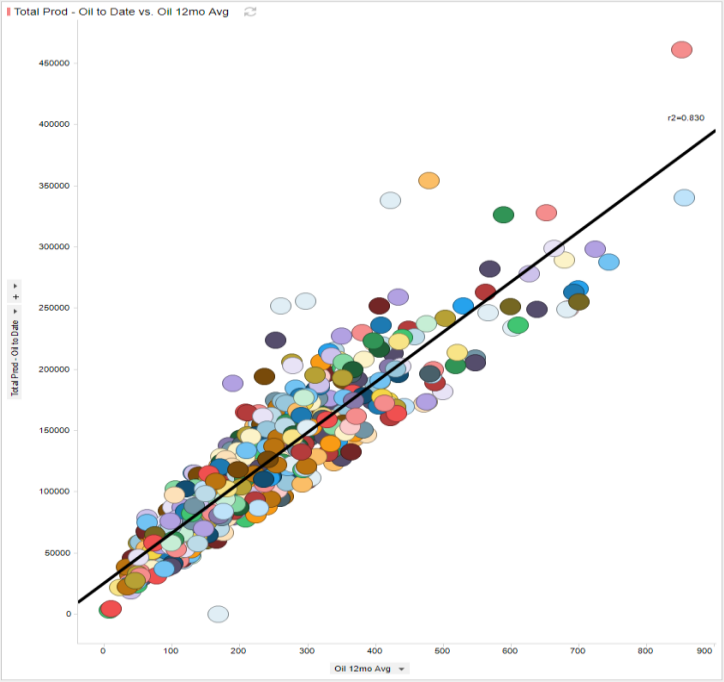

To normalize the wells and their production, we selected average oil production of the first 12 months of every well. The graphs show that it will be a good indicator to predict production. Comparing the histogram of total oil production (above) vs first 12 month production (below), with the cross-plot between both variables shows a high correlation coefficient of 0,830.

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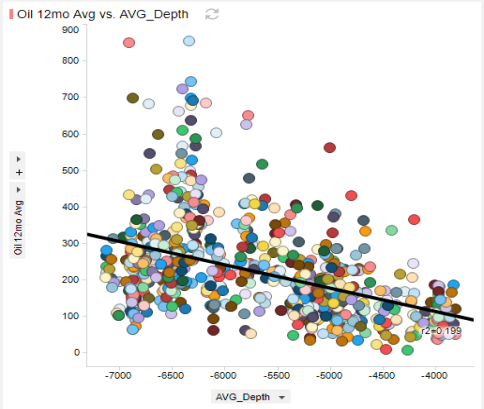

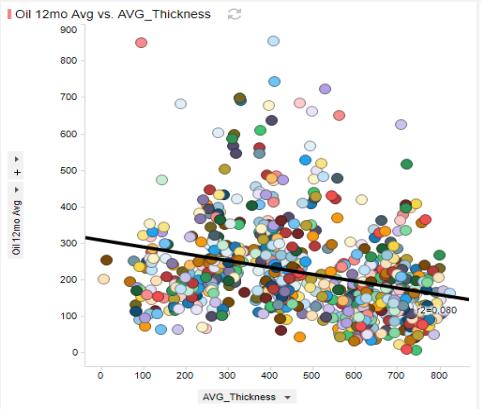

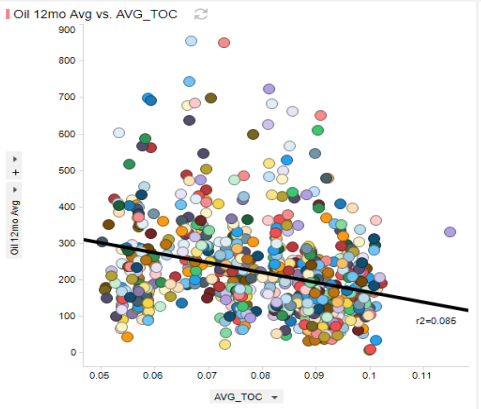

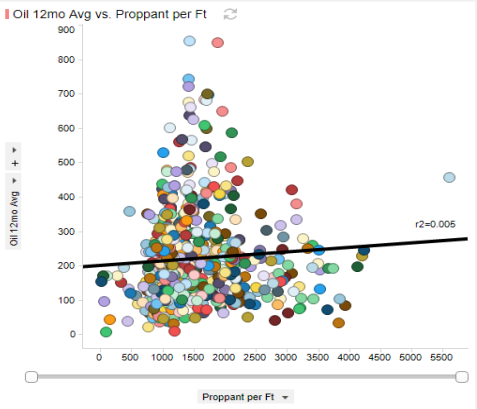

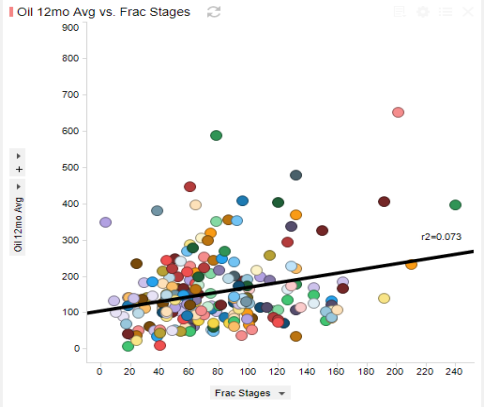

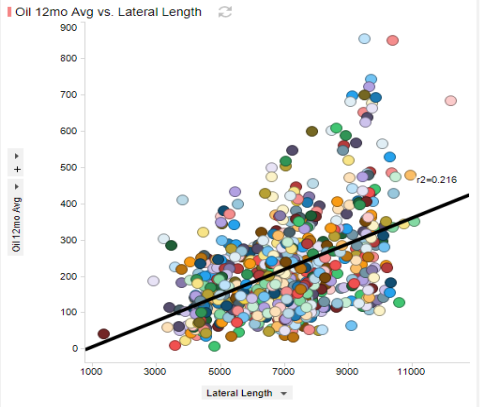

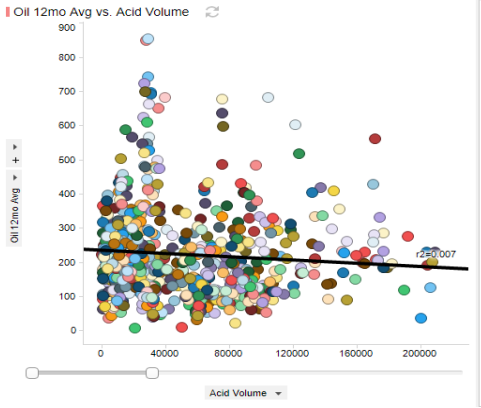

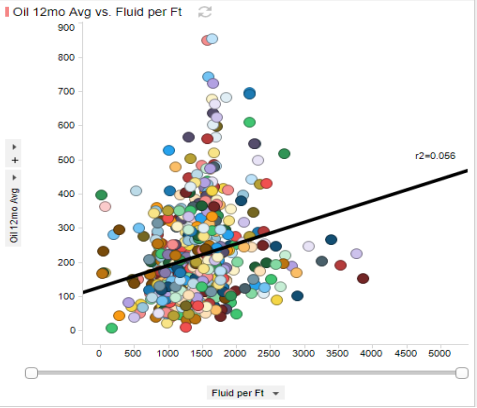

Above are crossplots highlighting average production of the first 12 months versus different geological and engineering properties. Notice that by itself, none of the variables correlates high with production

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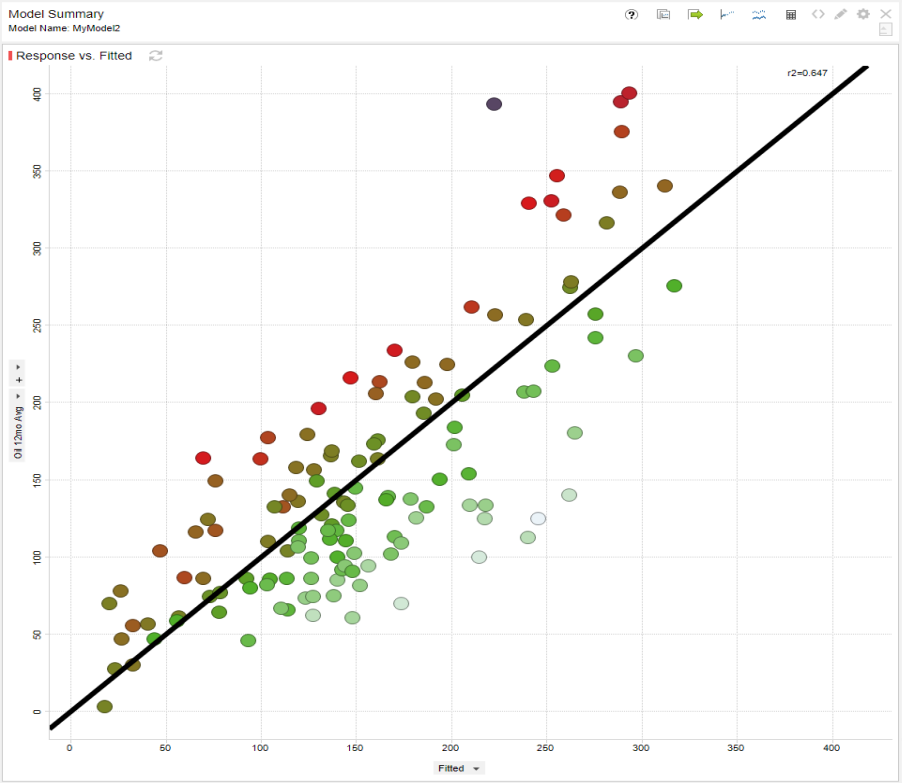

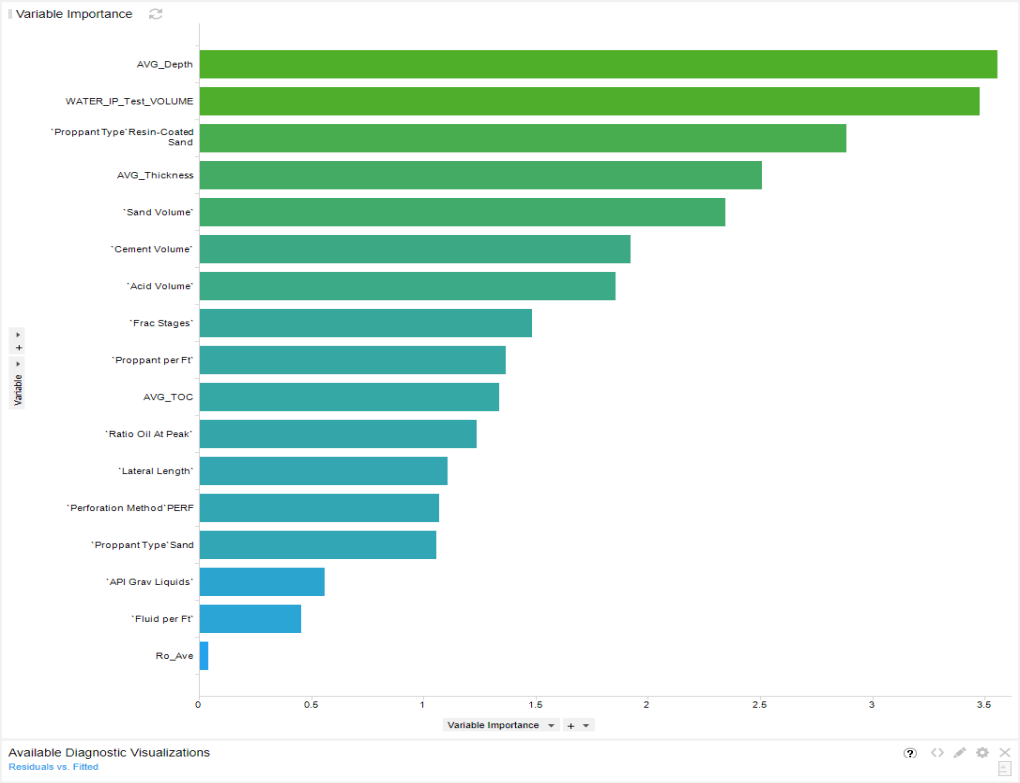

In this study, we run a lineal regression modeling technique to combine every variable to predict production. The results shows a correlation coefficient of 0.647 between predicted first 12 month production versus 12 months production (left). On the right one can see the variable importance for the model in decreasing order, and thus their weight or contribution on the final model

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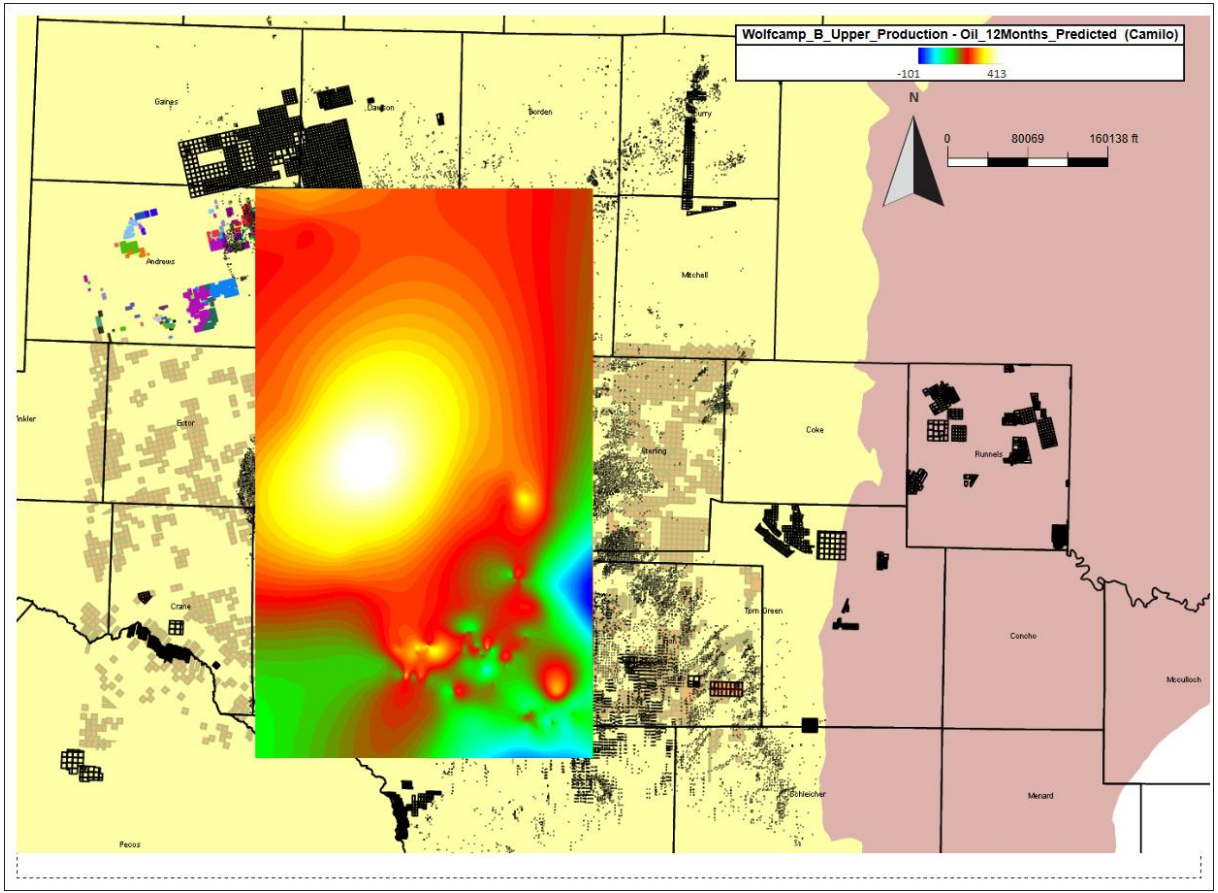
First 12 months average production prediction map.

This predicted map assumes that all the wells in the area were drilled with same engineering parameters (horizontal length, frac stages, fluids volumes, etc.). The variables were normalized to their optimum predicted values.



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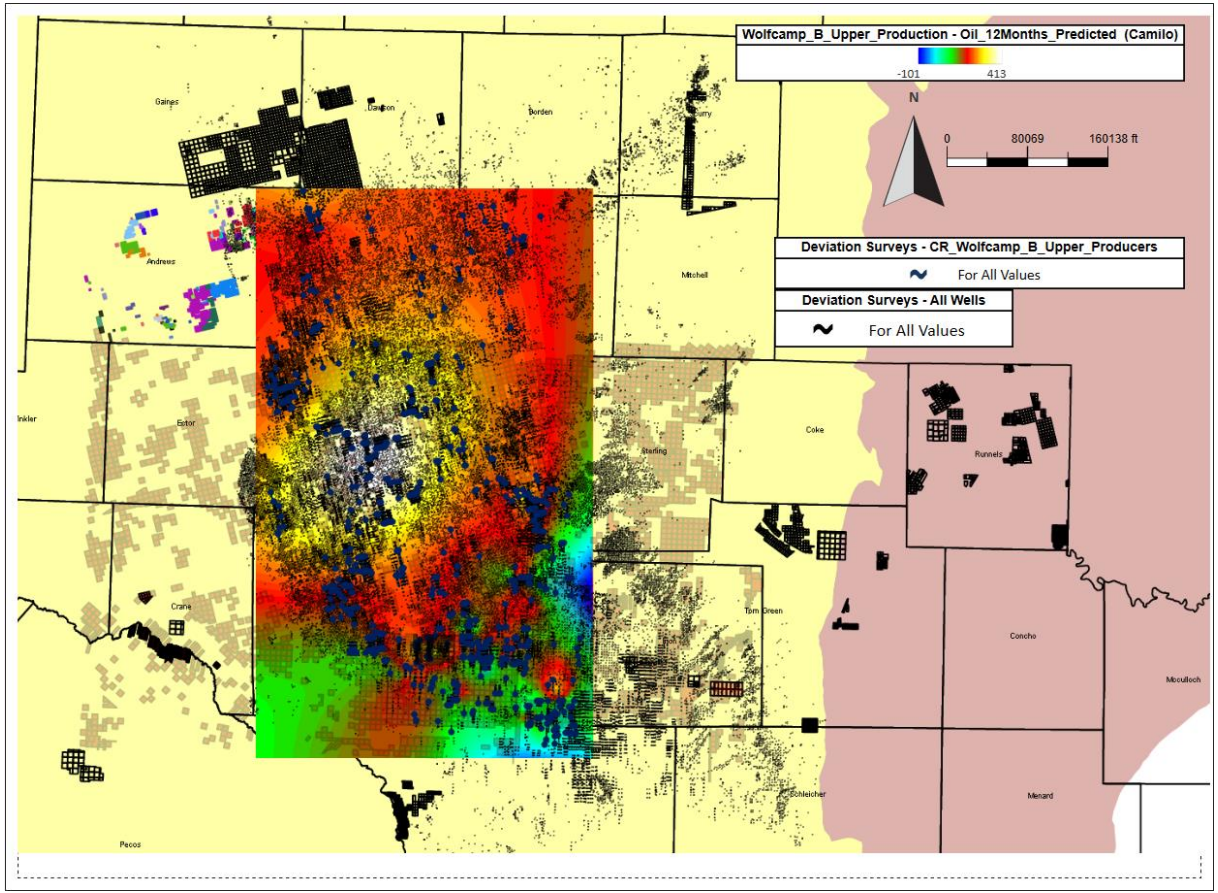
First 12 months average production prediction map. Over posting are: Wolfcamp B producers wells in blue (all of them are horizontals), in black all the other wells in the Midland basin producing from other formations, and underneath the map and wells, one can see the leases. GIS Buffering technology is imperative to eliminate the influence of current drainage areas, geohazards and lease regulations.



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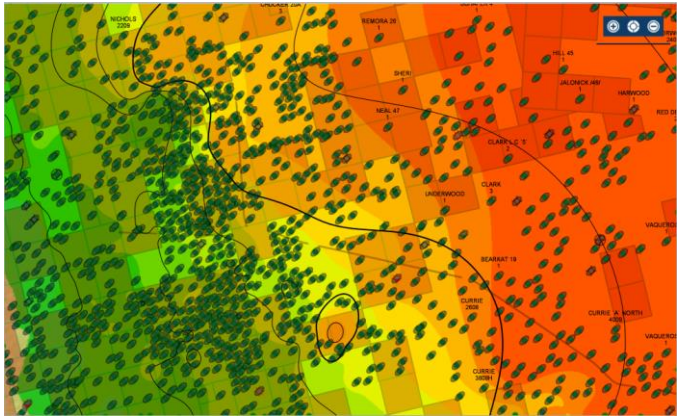

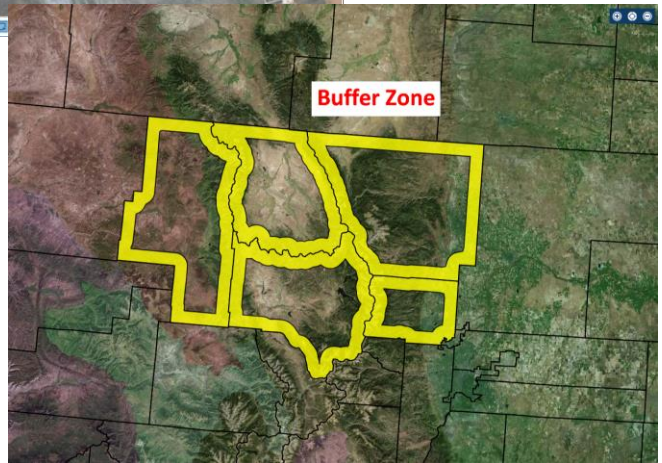

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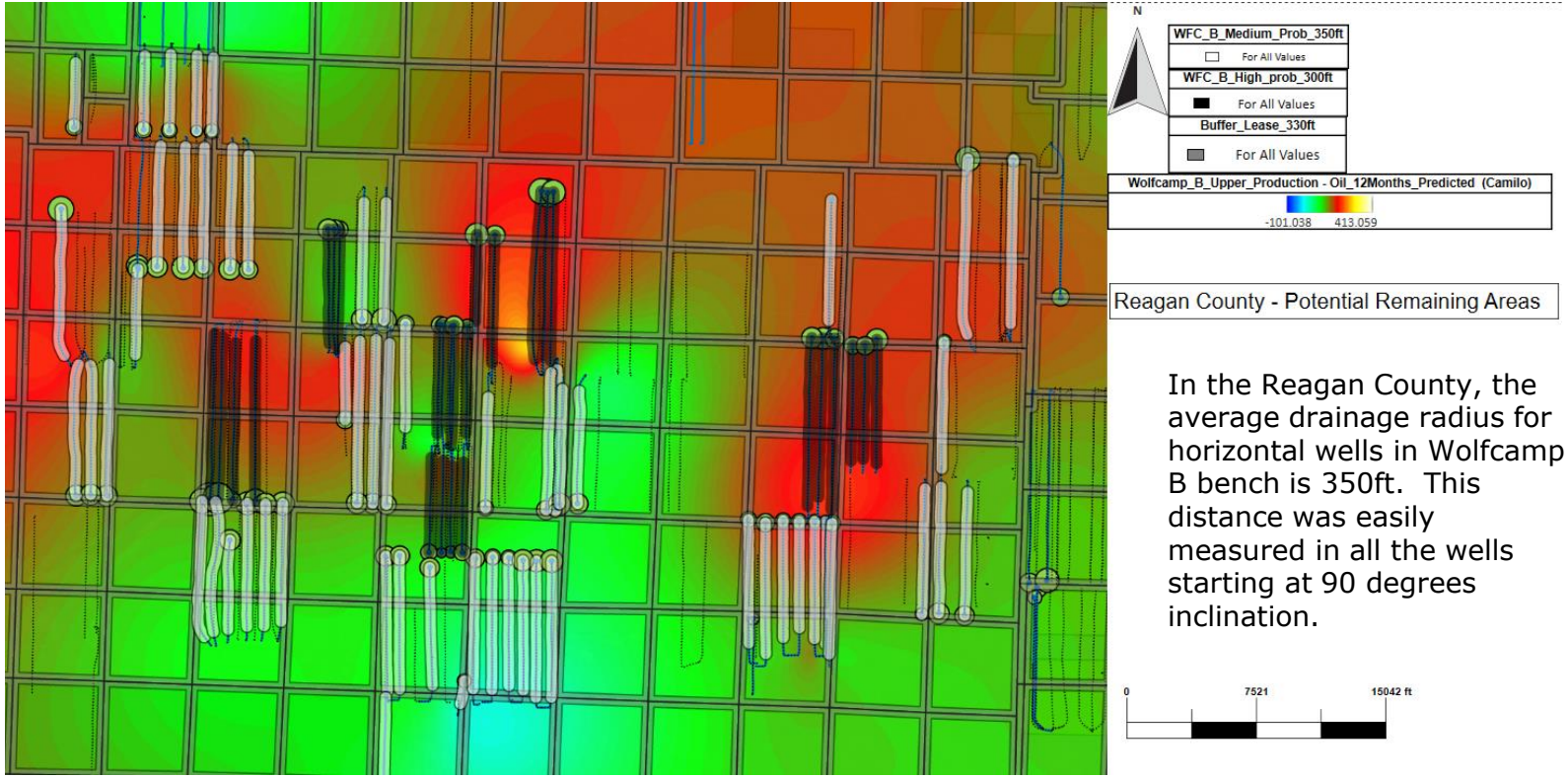

Reagan County - Potential Remaining Areas

In the Reagan County, the average drainage radius for horizontal wells in Wolfcamp B bench is 350ft. This distance was easily measured in all the wells starting at 90 degrees inclination.

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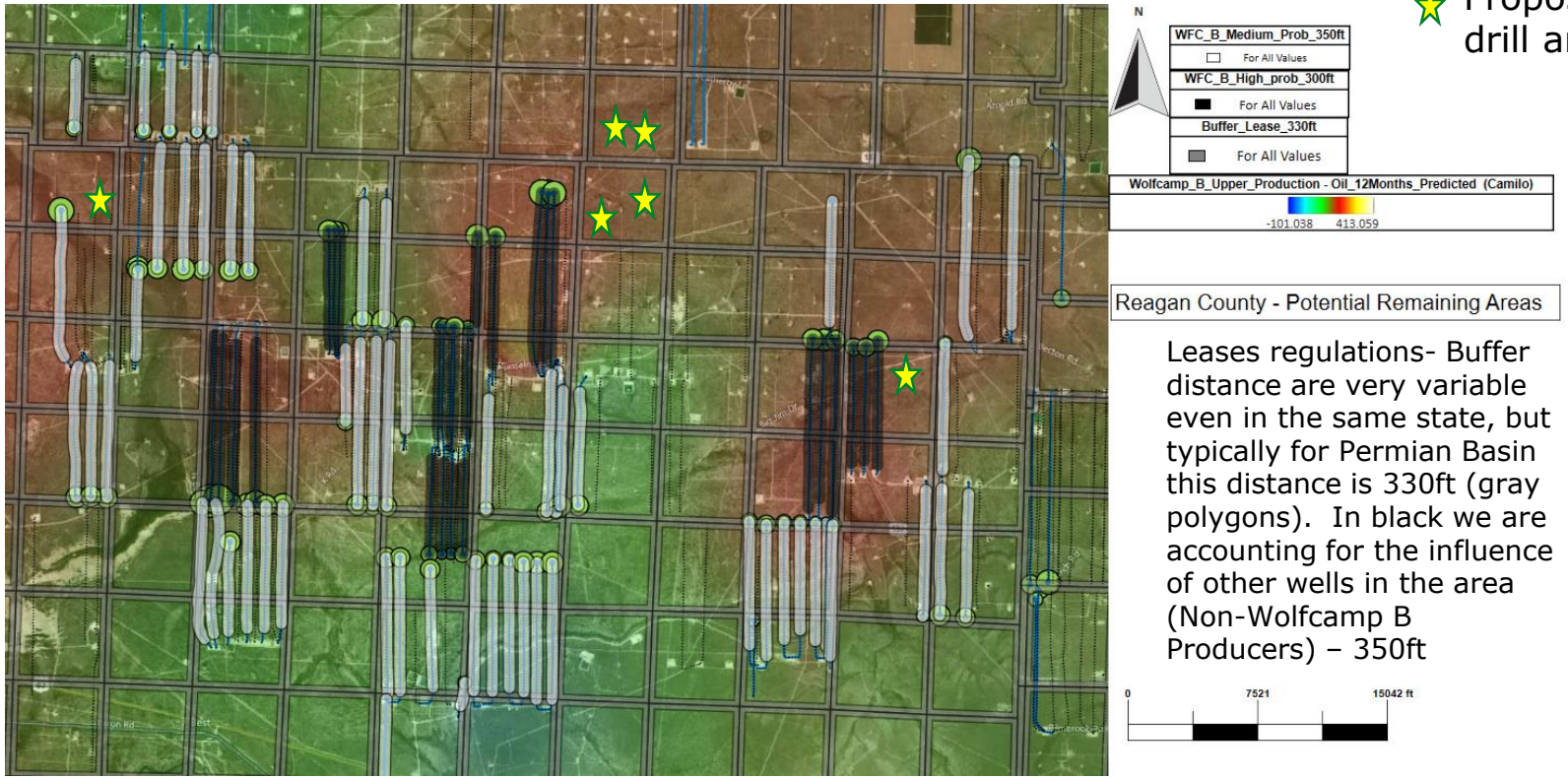

Proposed drill areas

Leases regulations- Buffer distance are very variable even in the same state, but typically for Permian Basin this distance is 330ft (gray polygons). In black we are accounting for the influence of other wells in the area (Non-Wolfcamp B Producers) – 350ft

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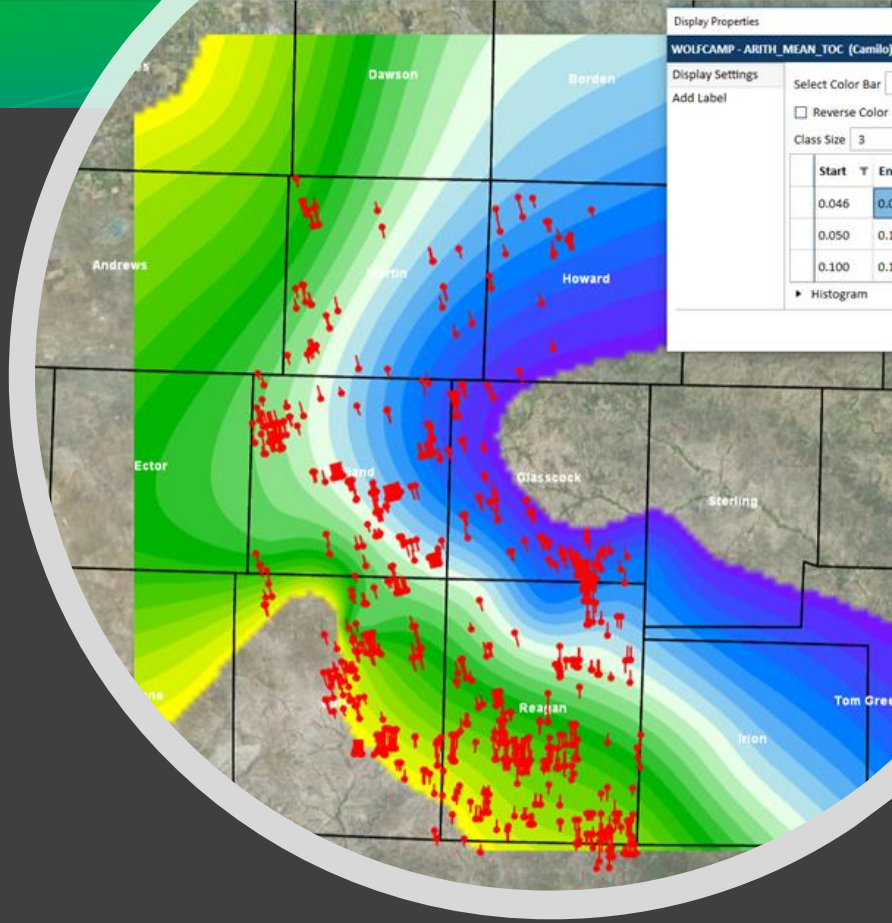
Conclusions

- Advances in ESRI technology allows the geologists and engineers to apply advance opacity control in their maps to identify key data trends and their correlation with the most productive wells.
- Geological mapping is advancing in the direction of data analytics. In unconventional reservoirs, the optimum drilling areas are not longer a function of key geological, geophysical or petrophysical properties; it is now function of all of the above combined with rock mechanics, geochemistry, drilling and completions parameters. Advance multivariate analytics techniques are used get fewer maps that include all the information available. In this work, multi-lineal regression techniques were used to predict 12 months average oil production and mapped the results.



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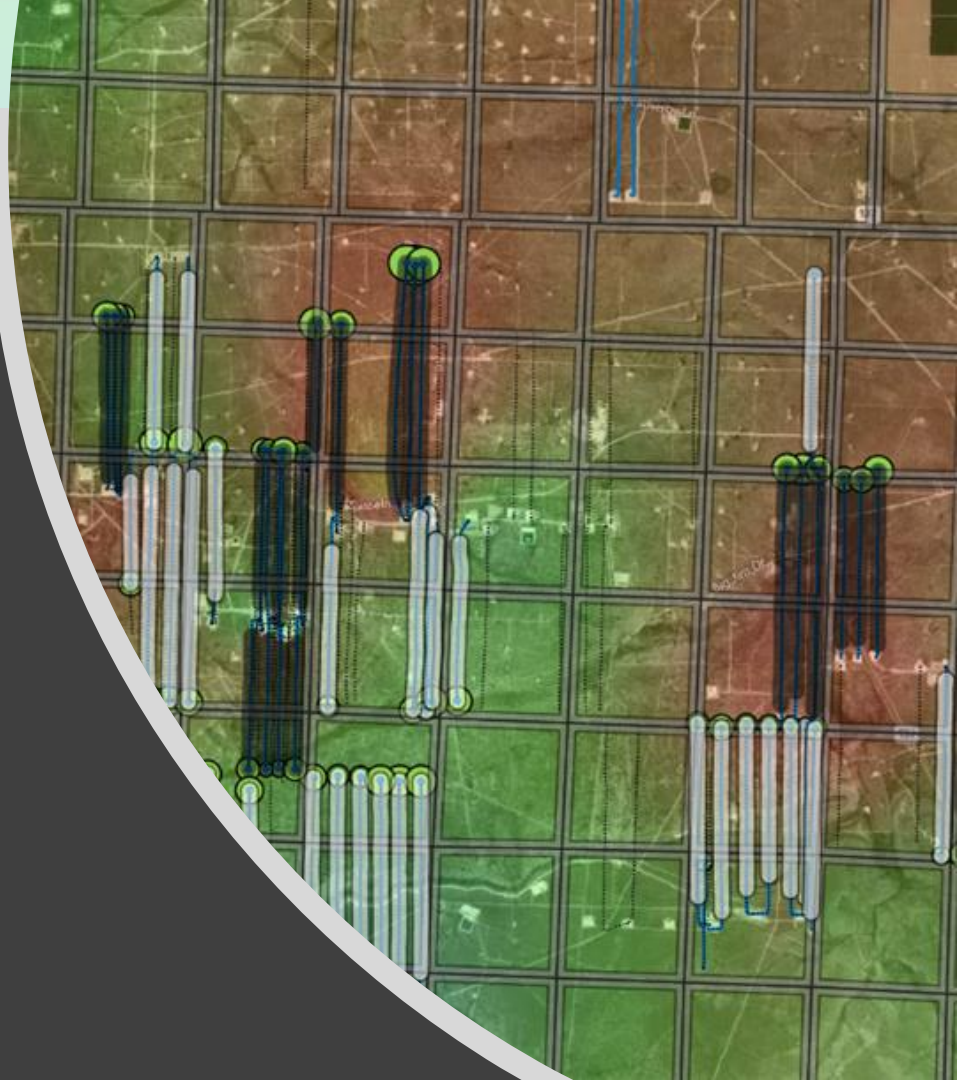
Conclusions

- In highly well populated areas, the final maps have to be combined with advance buffering technology to quickly detect and account for the influence of drainage areas in existing wells (vertical or horizontal), keep reasonable distance from other wells targeting other producing formations, lease regulations, pipelines, and geohazards (rivers, roads, protected areas), etc. This buffering technology in combination with geological mapping is the new foundation for field planning.
- Buffering technology allows distance calculation from any layer (cultural or interpretative), using different methodologies depending on the layer. In this study, for example, drainage areas for horizontal wells were tied to the deviation survey of every well.
- The buffer areas were subtracted from the calculated production prediction map to result in the final proposed areas to drill.



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