Wood Mackenzie
A Verisk Analytics Business

Using ArcGIS to improve play valuations

Jessica Van Slyke, Nate Wysocki, Rita Asagwara & Kyle Neely

ESRI Petroleum GIS Conference, April 2017

Using ArcGIS to improve play evaluation

Agenda

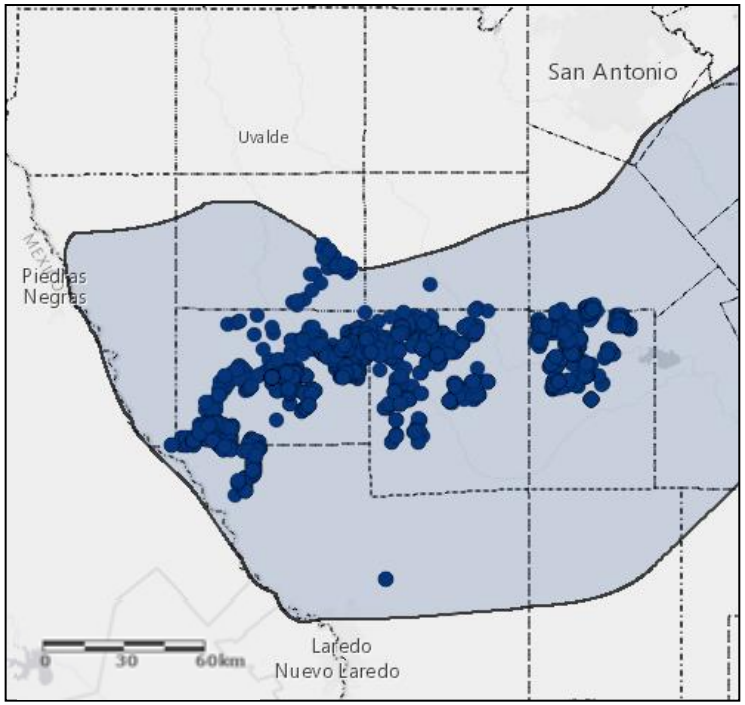
- Introduction
- Process overview
- Barnett case study
- Risk factor and well costs
- Impacts to valuation

Introduction

There is a need for GIS in play evaluation

- Wood Mackenzie created a business case for stronger integration of GIS into workflows
- We developed an easy-to-use platform through ArcGIS Online where non-GIS users could perform analysis and develop maps
- US L48 Research team widely adopts platform and uses it to improve granular play evaluation
  - » **Before:** Sub-plays based on county lines and/or general understanding of spatial distribution of hydrocarbon type and well productivity.
  - » **After:** Use ArcGIS online and collaborate with internal mapping team to dive more deeply into the data. Develop more granular, technically based sub-play breakouts to better analyze data.
- Improves upstream research analysis and detailed valuations for clients and research offerings
- Supports business case for deeper integration of GIS into Wood Mackenzie workflows.

Before



ESRI Basemap, Wood Mackenzie North America Well Analysis Tool

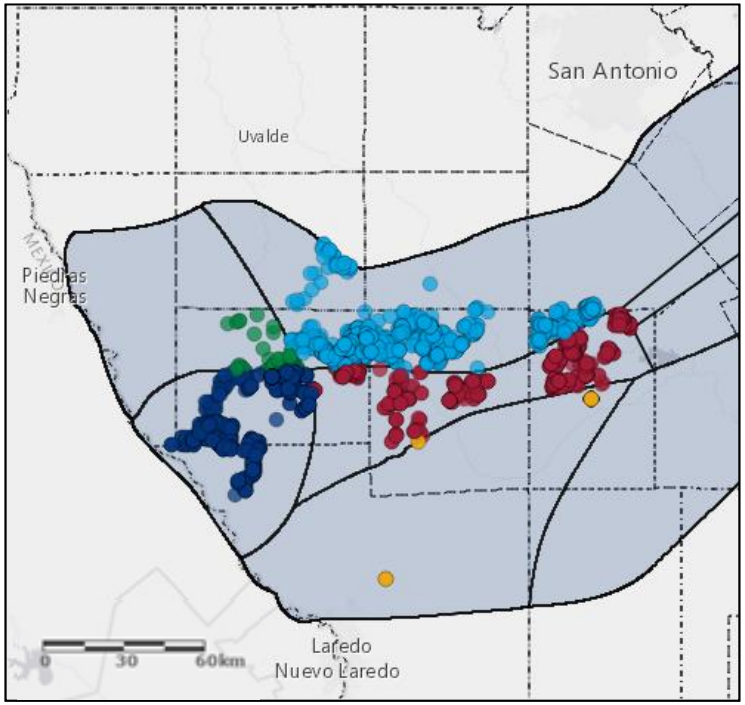
Wood Mackenzie
A Verisk Analytics Business

Introduction

There is a need for GIS in play evaluation

- Wood Mackenzie created a business case for stronger integration of GIS into workflows
- We developed an easy-to-use platform through ArcGIS Online where non-GIS users could perform analysis and develop maps
- US L48 Research team widely adopts platform and uses it to improve granular play evaluation
  - » **Before:** Sub-plays based on county lines and/or general understanding of spatial distribution of hydrocarbon type and well productivity.
  - » **After:** Use ArcGIS online and collaborate with internal mapping team to dive more deeply into the data. Develop more granular, technically based sub-play breakouts to better analyze data.
- Improves upstream research analysis and detailed valuations for clients and research offerings
- Supports business case for deeper integration of GIS into Wood Mackenzie workflows.

After



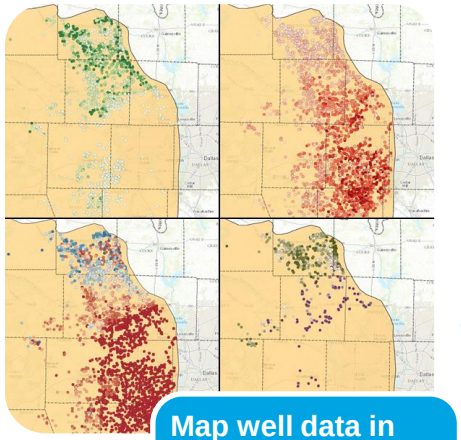
ESRI Basemap, Wood Mackenzie North America Well Analysis Tool

Wood Mackenzie
A Verisk Analytics Business

Sub-play definition process

Use ArcGIS online and collaboration with internal mapping to define technically based sub-plays

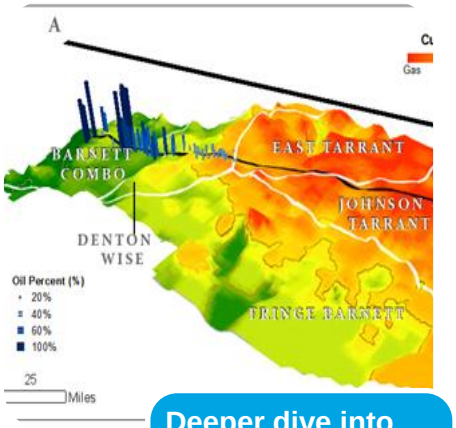
Simple mapping



Map well data in ArcGIS Online

- Productivity
- Percent oil
- API Gravity
- Vertical depth
- Well cost

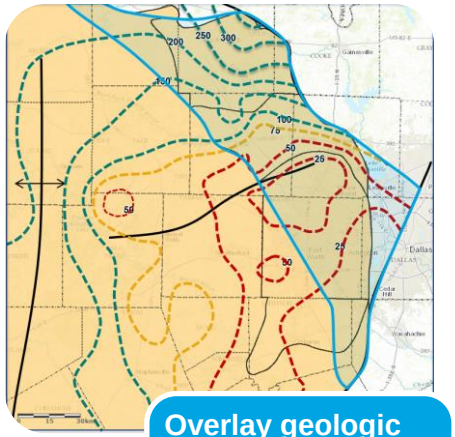
Collaboration with GIS analysts



Deeper dive into data

- Combine datasets
- Create surfaces
- Display in ArcPro

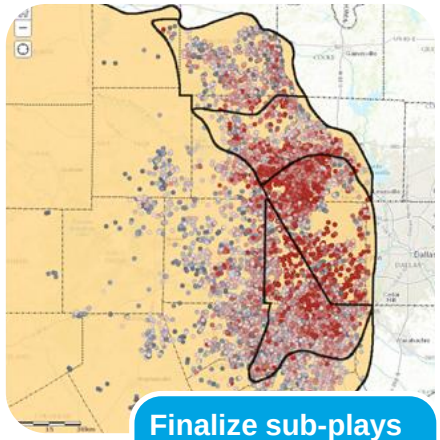
Confirm and explain with geology



Overlay geologic maps

- Vertical depth
- Thickness
- Thermal maturity
- Fracture barriers
- Faults

Finalize sub-plays

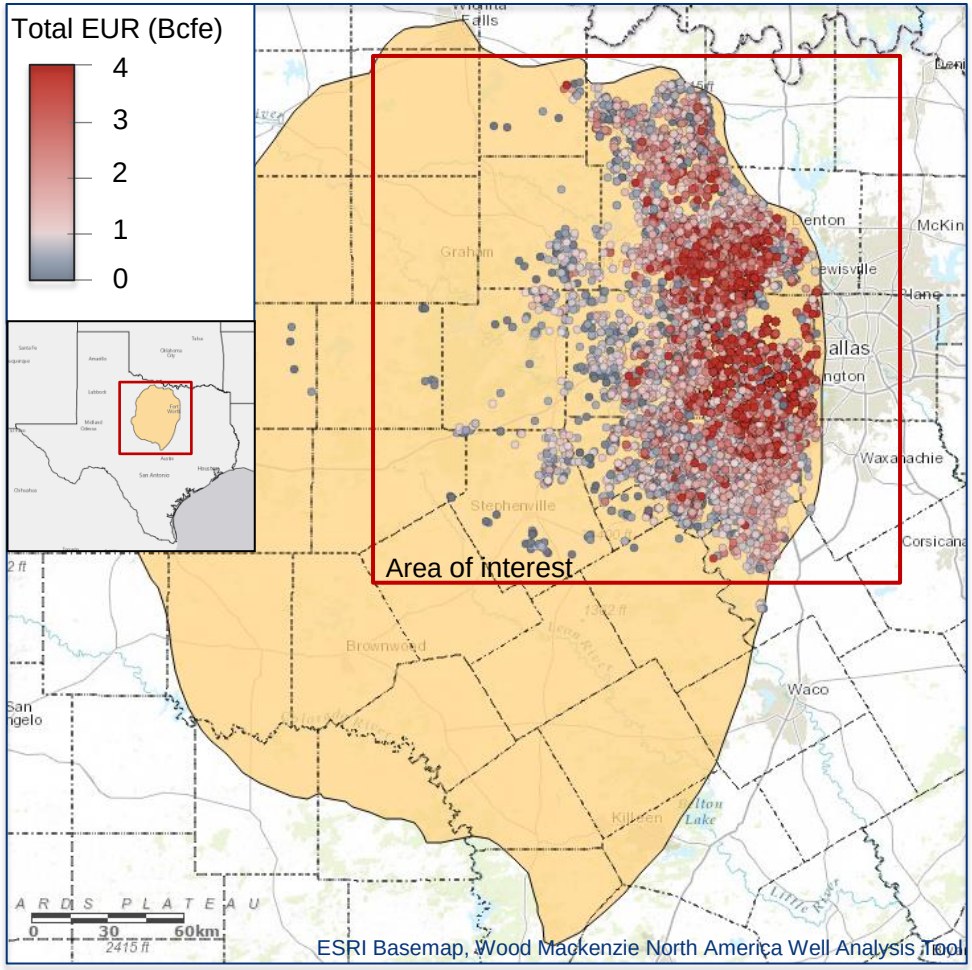


Finalize sub-plays

- Developing risking factor
- Analyze well costs and type curves

Barnett Shale case study

Well performance varies across the Barnett Shale, with best wells concentrated in the east

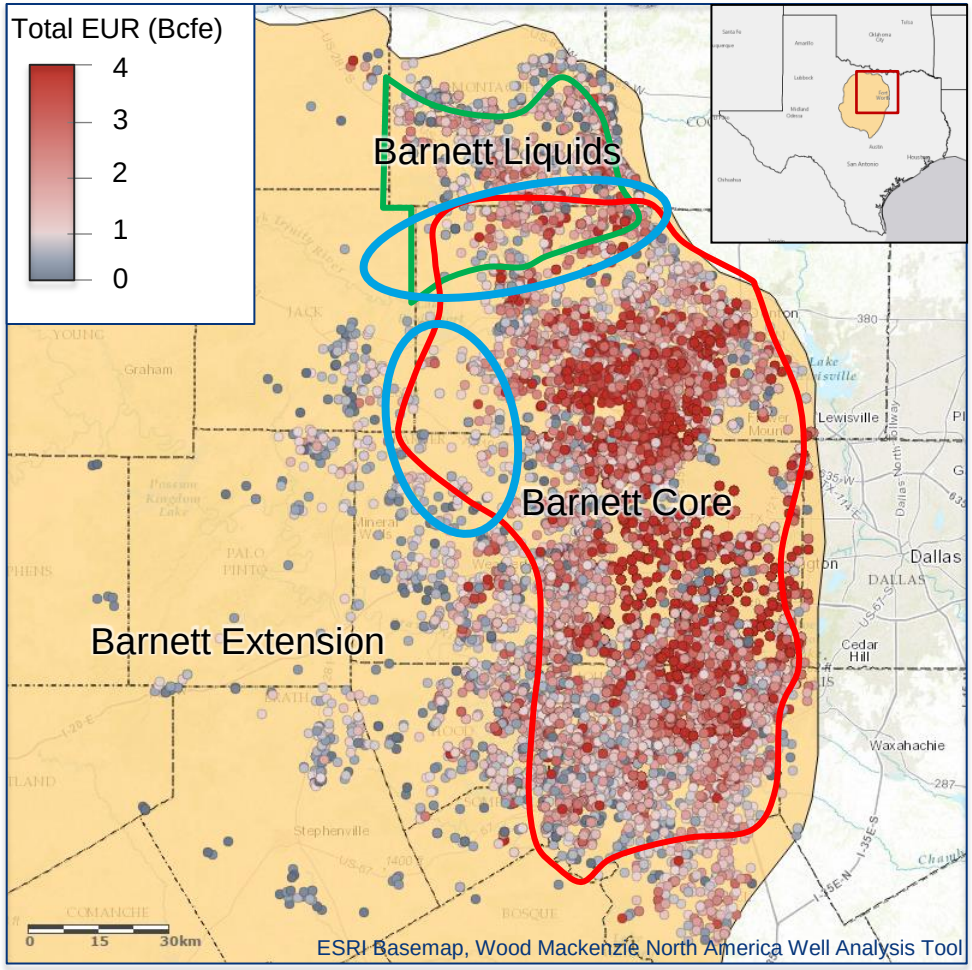


- Barnett Shale overview
- First pass look at well productivity across the basin
- Large 'fringe Barnett' area
- Most wells are drilled in the northeast quadrant of play

Wood Mackenzie
A Verisk Analytics Business

Initial Barnett play analysis

Previous analysis based on large, unconstrained sub-plays.

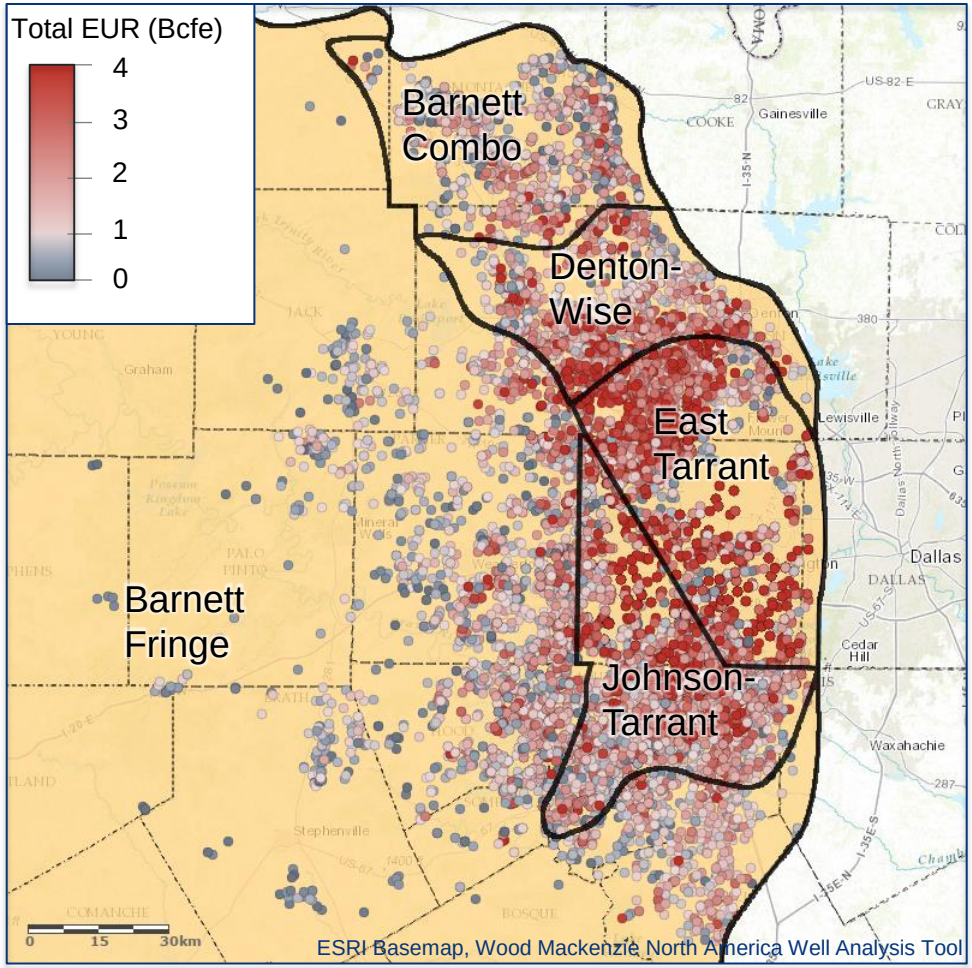


- Overlapping sub-plays
- Transitional area between dry gas and liquids is undefined
- Core area not constrained to well data alone
- Lack of clarity on how to analyze the Barnett effectively

Wood Mackenzie
A Verisk Analytics Business

Final sub-play delineation is much more granular

Sub-plays based on more than strictly well performance

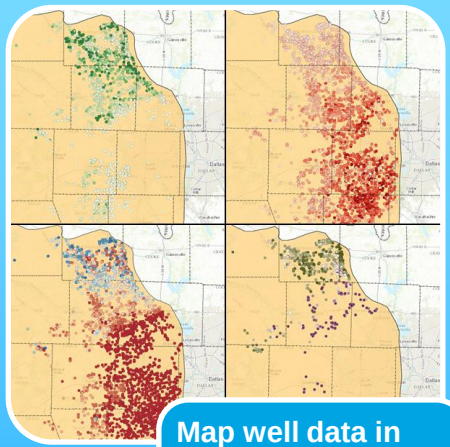


- We divided the Barnett into five distinct sub-plays
  - » Barnett Combo (liquids)
  - » Denton-Wise (condensate/wet gas)
  - » East Tarrant (Dry gas core)
  - » Johnson-Tarrant (Dry gas)
  - » Barnett Fringe (low productivity)

Sub-play definition process

Use ArcGIS online and collaboration with internal mapping to define technically based sub-plays

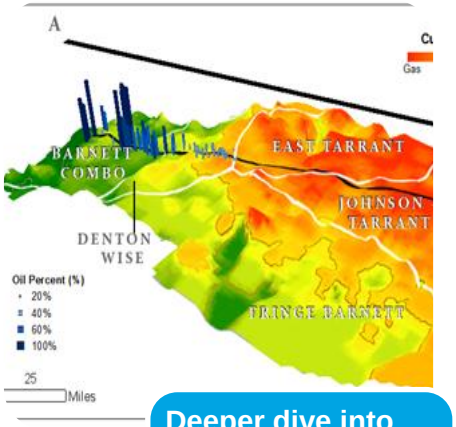
Simple mapping



Map well data in ArcGIS Online

- Productivity
- Percent oil
- API Gravity
- Vertical depth
- Well cost

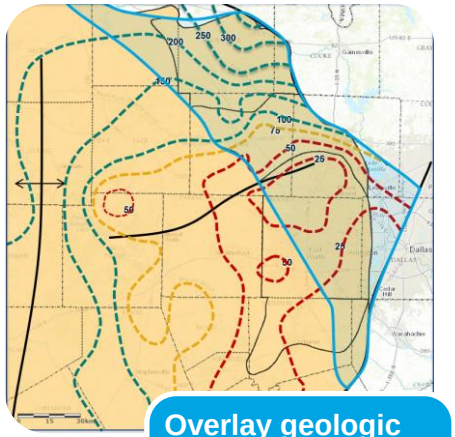
Collaboration with GIS analysts



Deeper dive into data

- Combine datasets
- Create surfaces
- Display in ArcPro

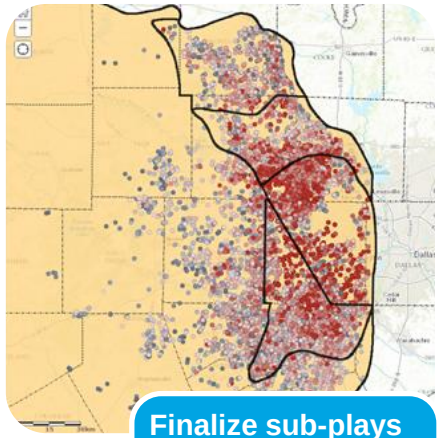
Confirm and explain with geology



Overlay geologic maps

- Vertical depth
- Thickness
- Thermal maturity
- Fracture barriers
- Faults

Finalize sub-plays

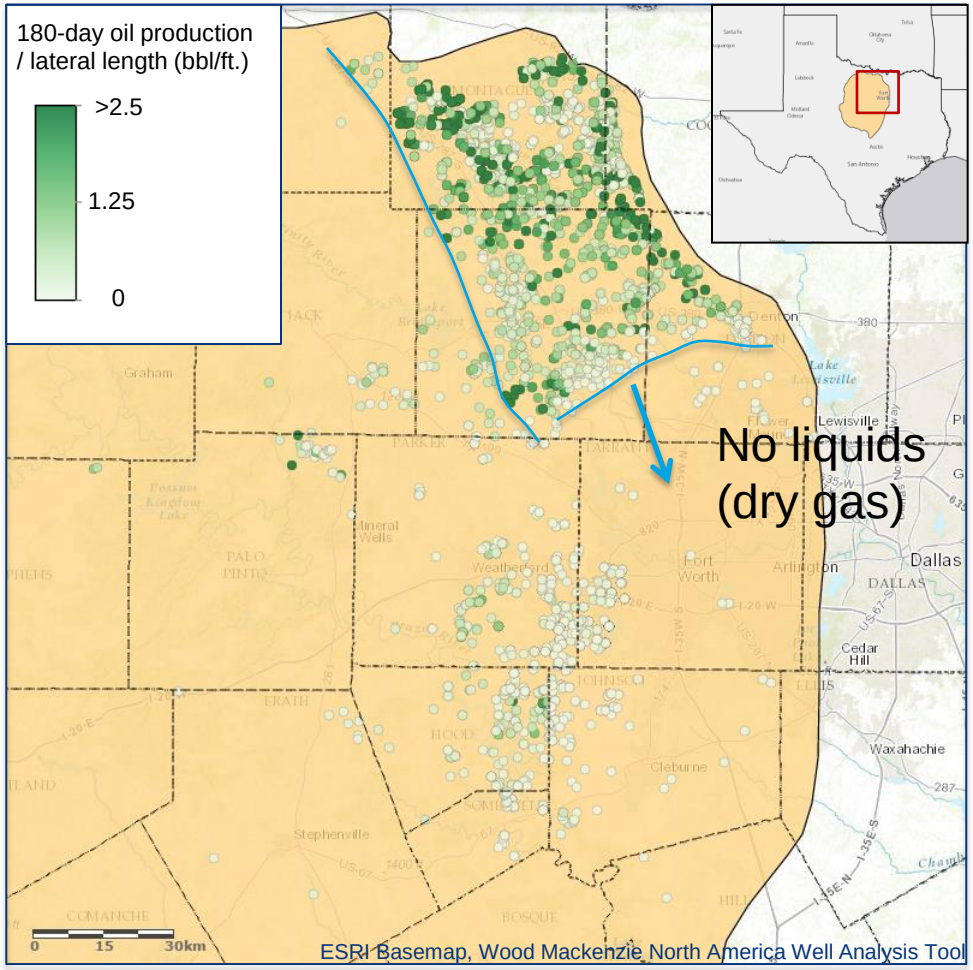


Finalize sub-plays

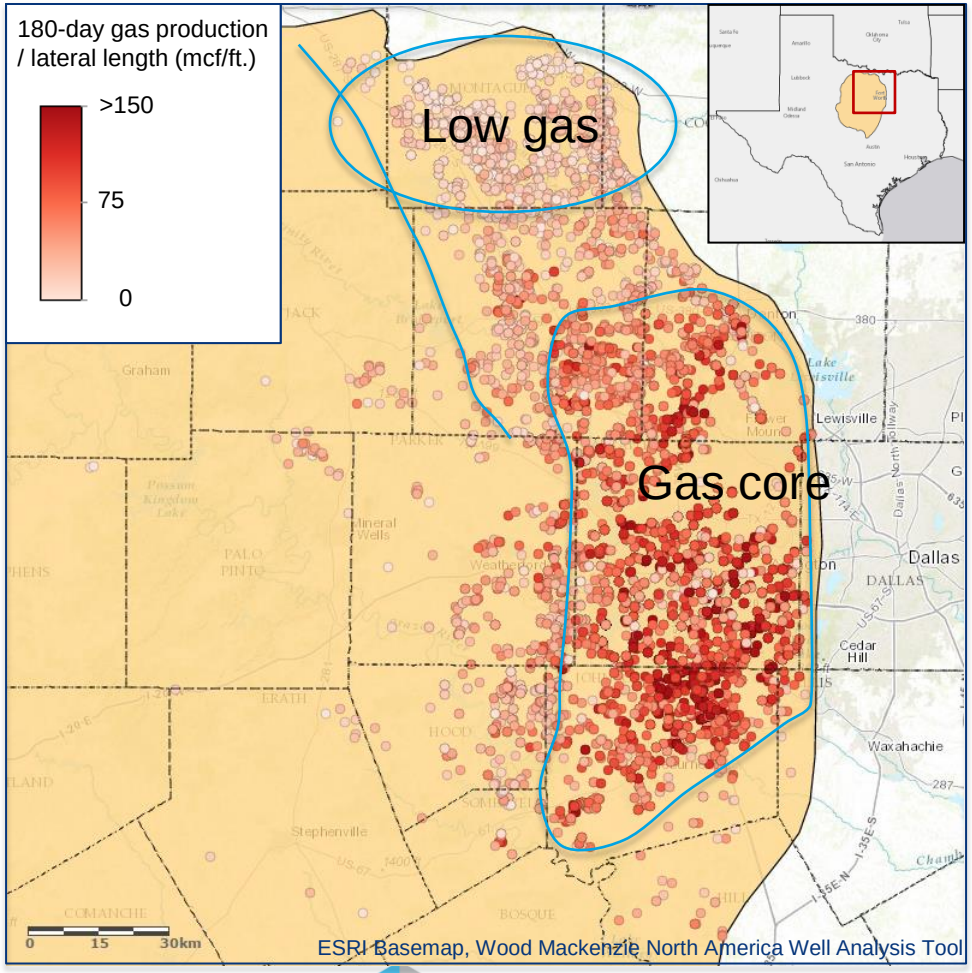
- Developing risking factor
- Analyze well costs and type curves

Barnett oil and gas productivity demonstrates clear patterns

Oil production



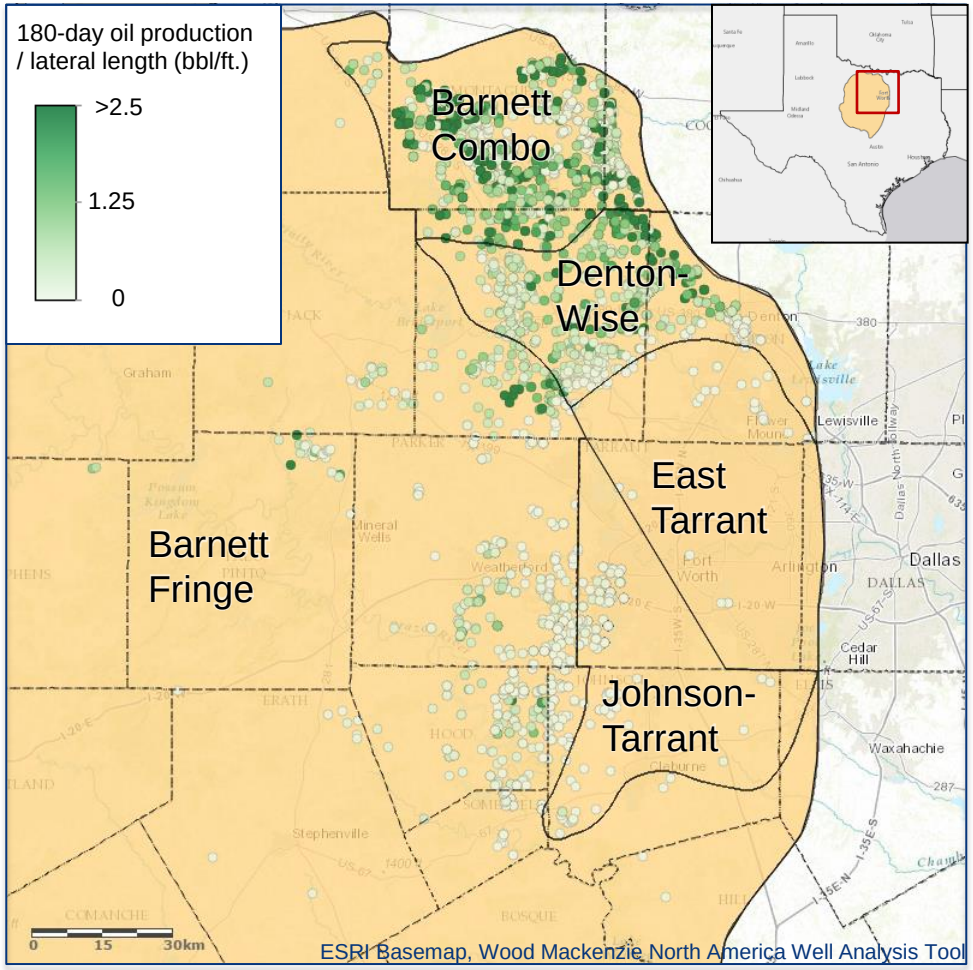
Gas production



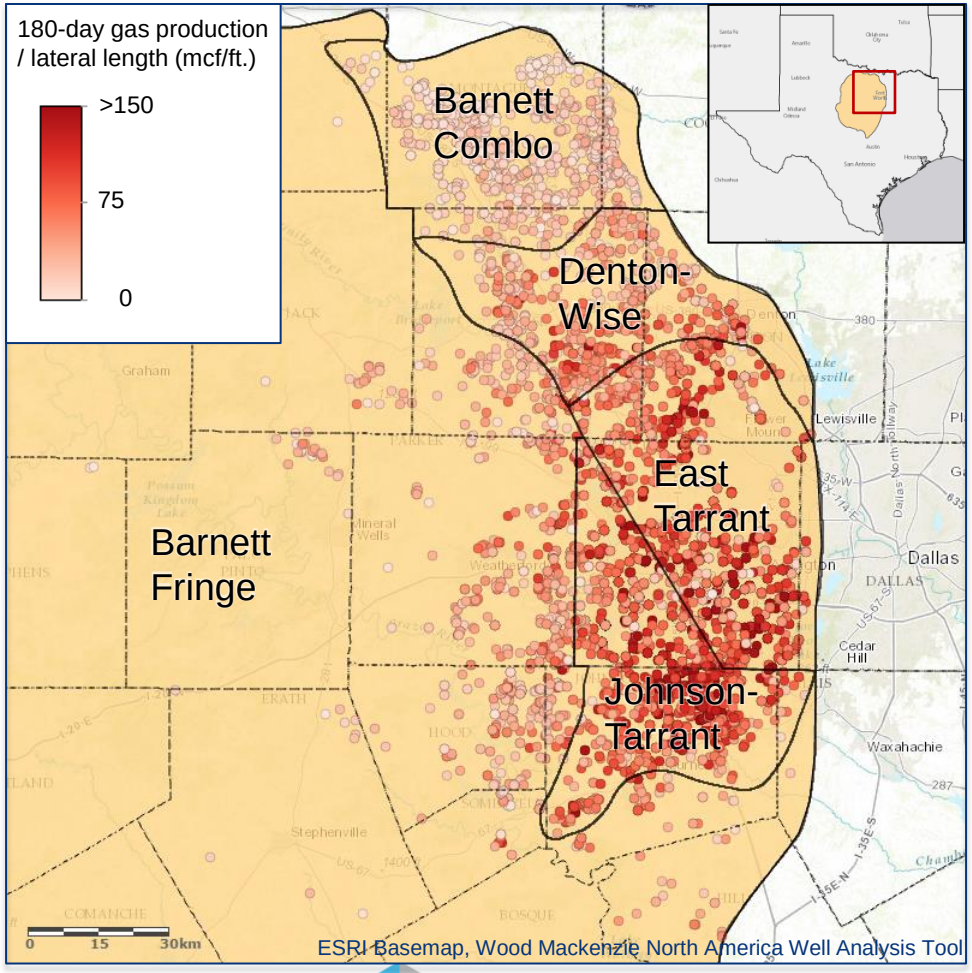
Wood Mackenzie
A Verisk Analytics Business

Barnett oil and gas productivity demonstrates clear patterns

Oil production



Gas production

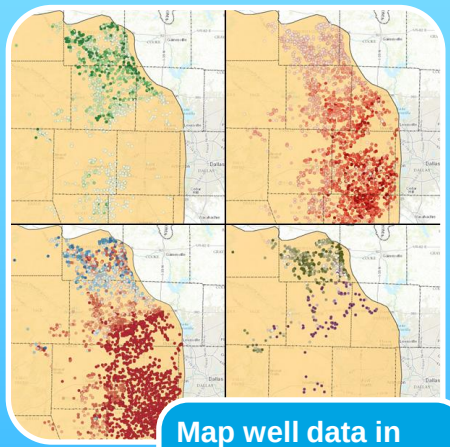


Wood Mackenzie
A Verisk Analytics Business

Sub-play definition process

Use ArcGIS online and collaboration with internal mapping to define technically based sub-plays

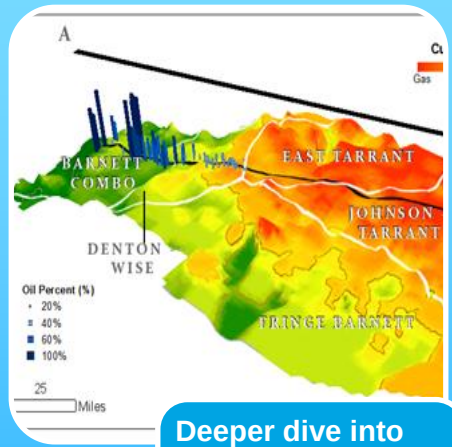
Simple mapping



Map well data in ArcGIS Online

- Productivity
- Percent oil
- API Gravity
- Vertical depth
- Well cost

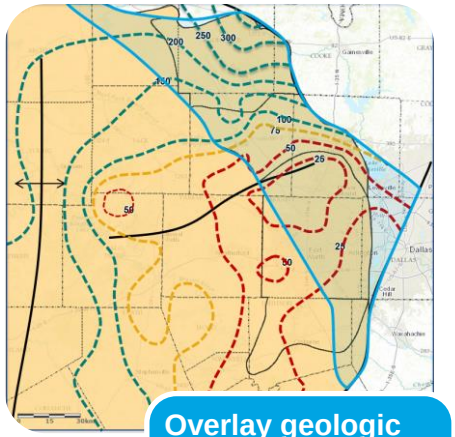
Collaboration with GIS analysts



Deeper dive into data

- Combine datasets
- Create surfaces
- Display in ArcPro

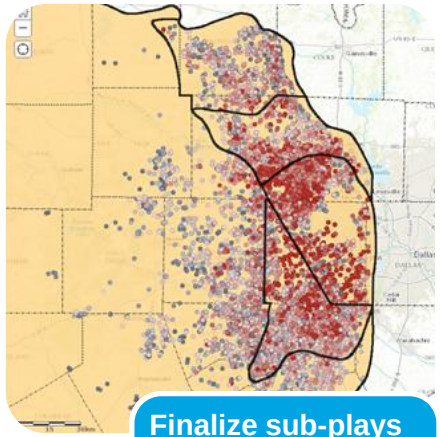
Confirm and explain with geology



Overlay geologic maps

- Vertical depth
- Thickness
- Thermal maturity
- Fracture barriers
- Faults

Finalize sub-plays



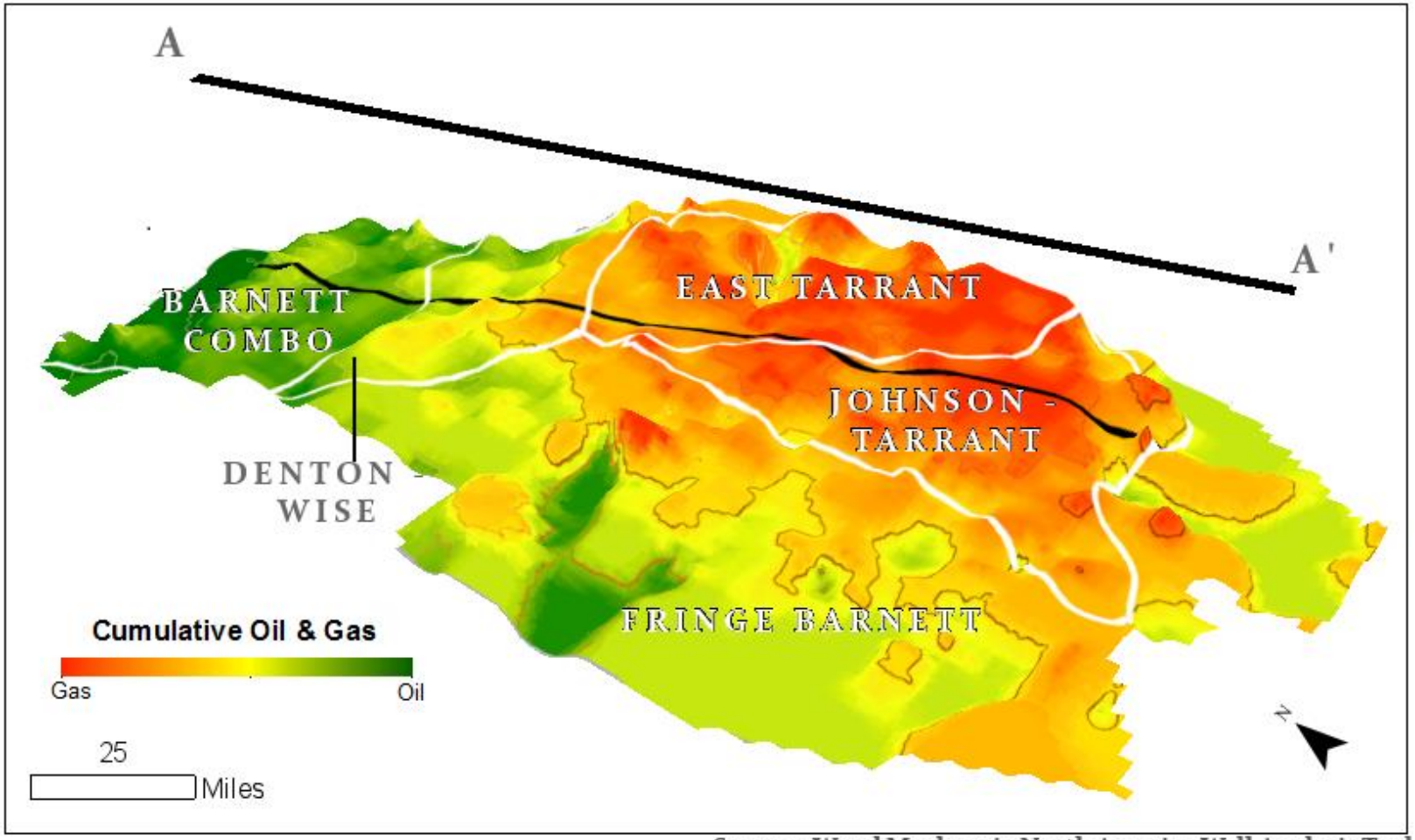
Finalize sub-plays

- Developing risking factor
- Analyze well costs and type curves

Wood Mackenzie
A Verisk Analytics Business

Taking a deeper dive into the data

Combine datasets to create cumulative oil and gas productivity surface

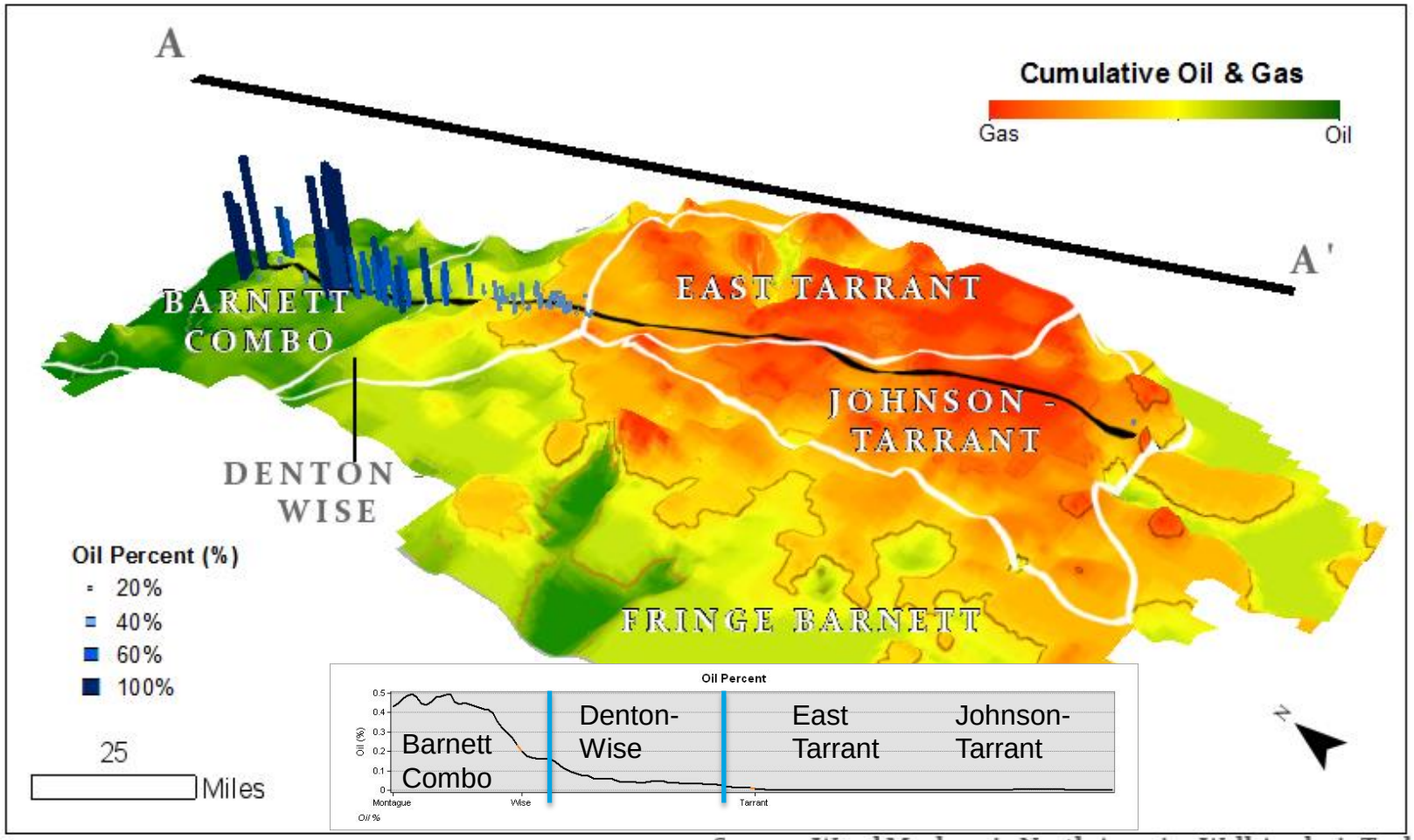


Source : Wood Mackenzie North America Well Analysis Tool

Wood Mackenzie
A Verisk Analytics Business

Taking a deeper dive into the data

Overlay percent oil to clarify trend

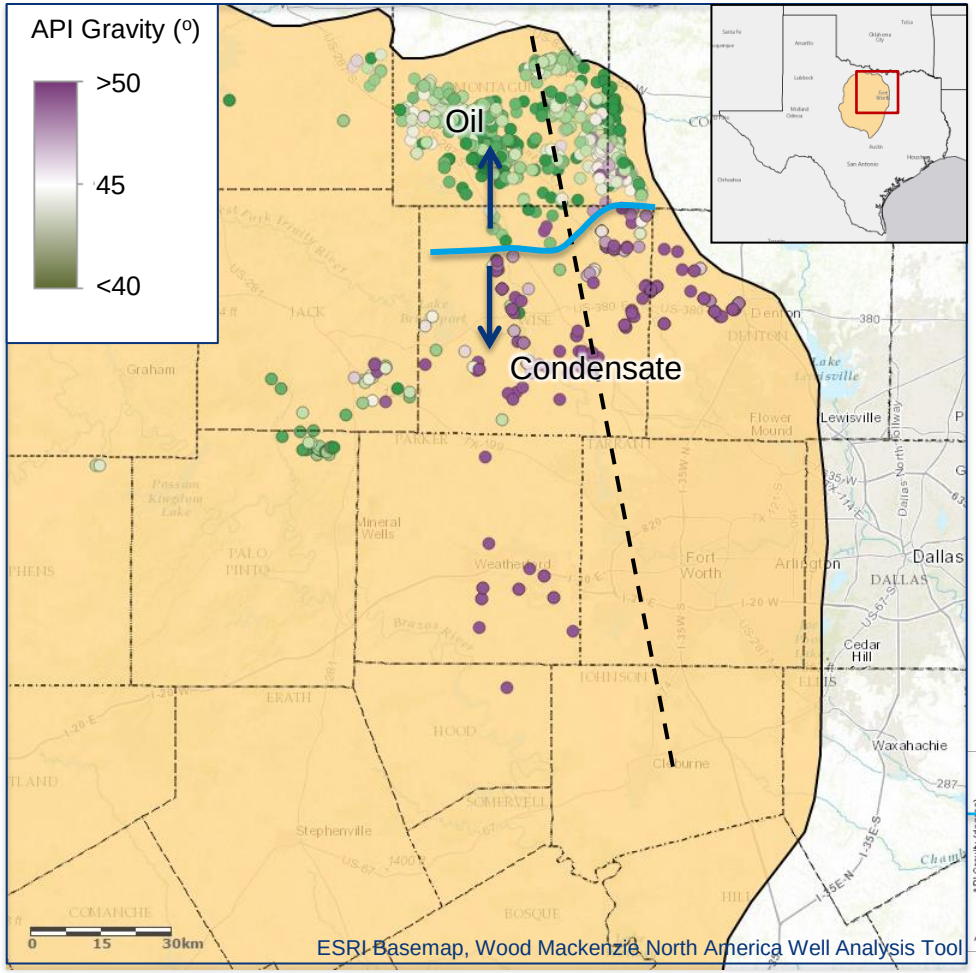


Source : Wood Mackenzie North America Well Analysis Tool

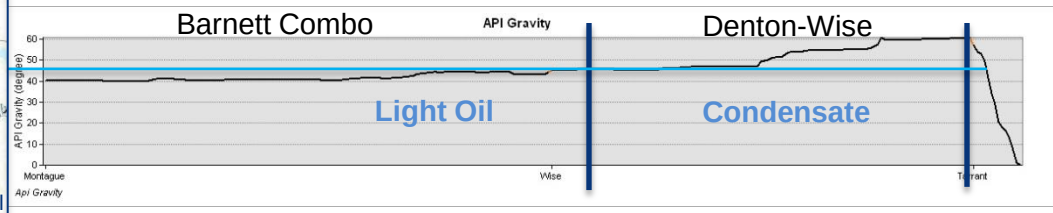
Wood Mackenzie
A Verisk Analytics Business

API Gravity guides boundary between liquids and wet gas sub-plays

Looking more closely at categorizing liquids production with API Gravity



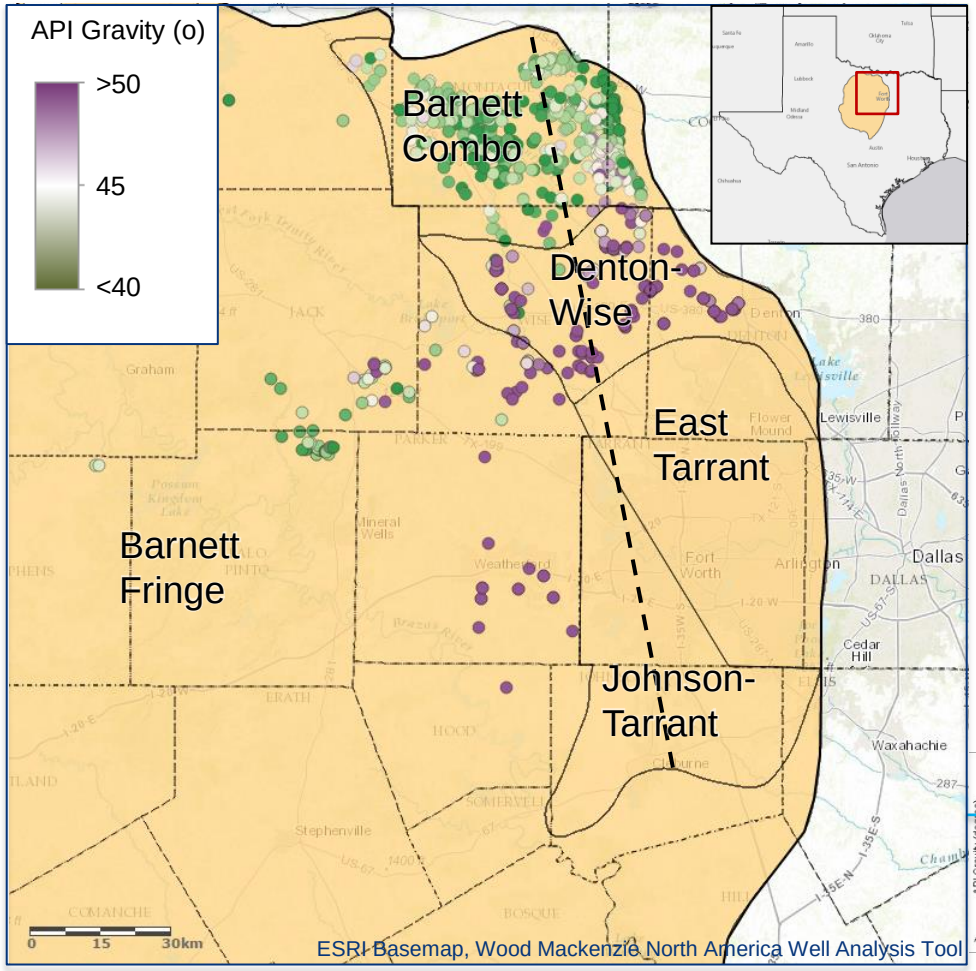
- API Gravity
  - » Condensate: above 45 degrees
  - » Oil: below 45 degrees
- It is evident that there are two liquids rich sub-plays – one light oil, one condensate/wet gas
- Further confirms southern limit of liquids.



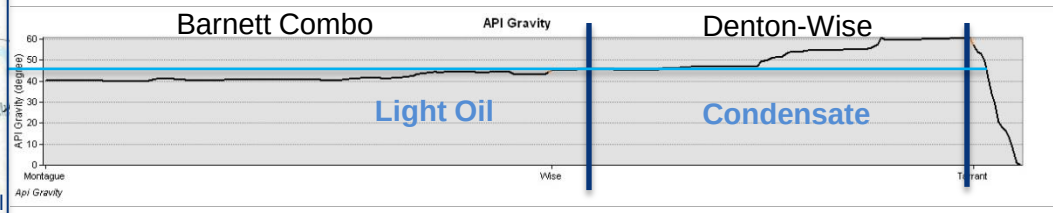
Wood Mackenzie
A Verisk Analytics Business

API Gravity guides boundary between liquids and wet gas sub-plays

Looking more closely at categorizing liquids production with API Gravity



- API Gravity
  - » Condensate: above 45 degrees
  - » Oil: below 45 degrees
- It is evident that there are two liquids rich sub-plays – one light oil, one condensate/wet gas
- Further confirms southern limit of liquids.

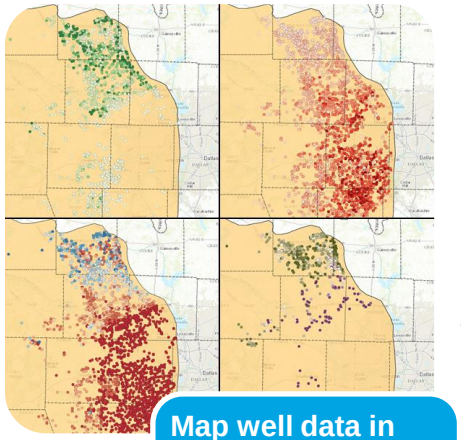


Wood Mackenzie
A Verisk Analytics Business

Sub-play definition process

Use ArcGIS online and collaboration with internal mapping to define technically based sub-plays

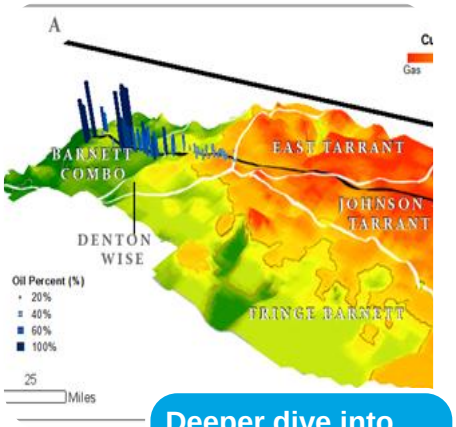
Simple mapping



Map well data in ArcGIS Online

- Productivity
- Percent oil
- API Gravity
- Vertical depth
- Well cost

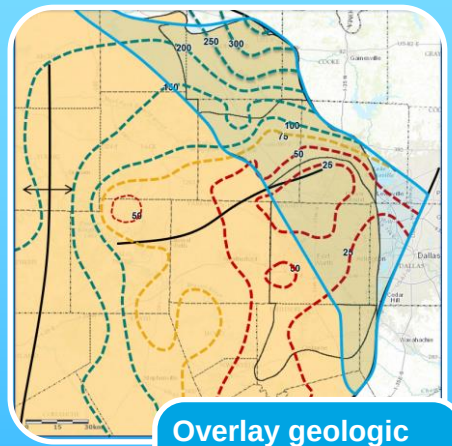
Collaboration with GIS analysts



Deeper dive into data

- Combine datasets
- Create surfaces
- Display in ArcPro

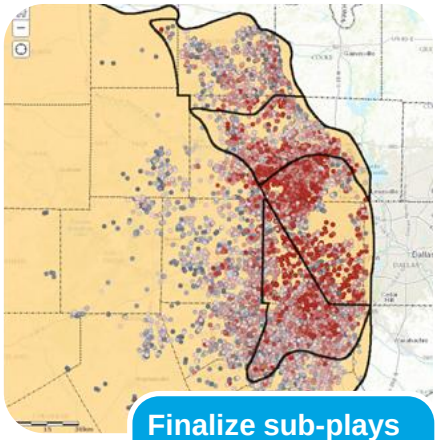
Confirm and explain with geology



Overlay geologic maps

- Vertical depth
- Thickness
- Thermal maturity
- Fracture barriers
- Faults

Finalize sub-plays



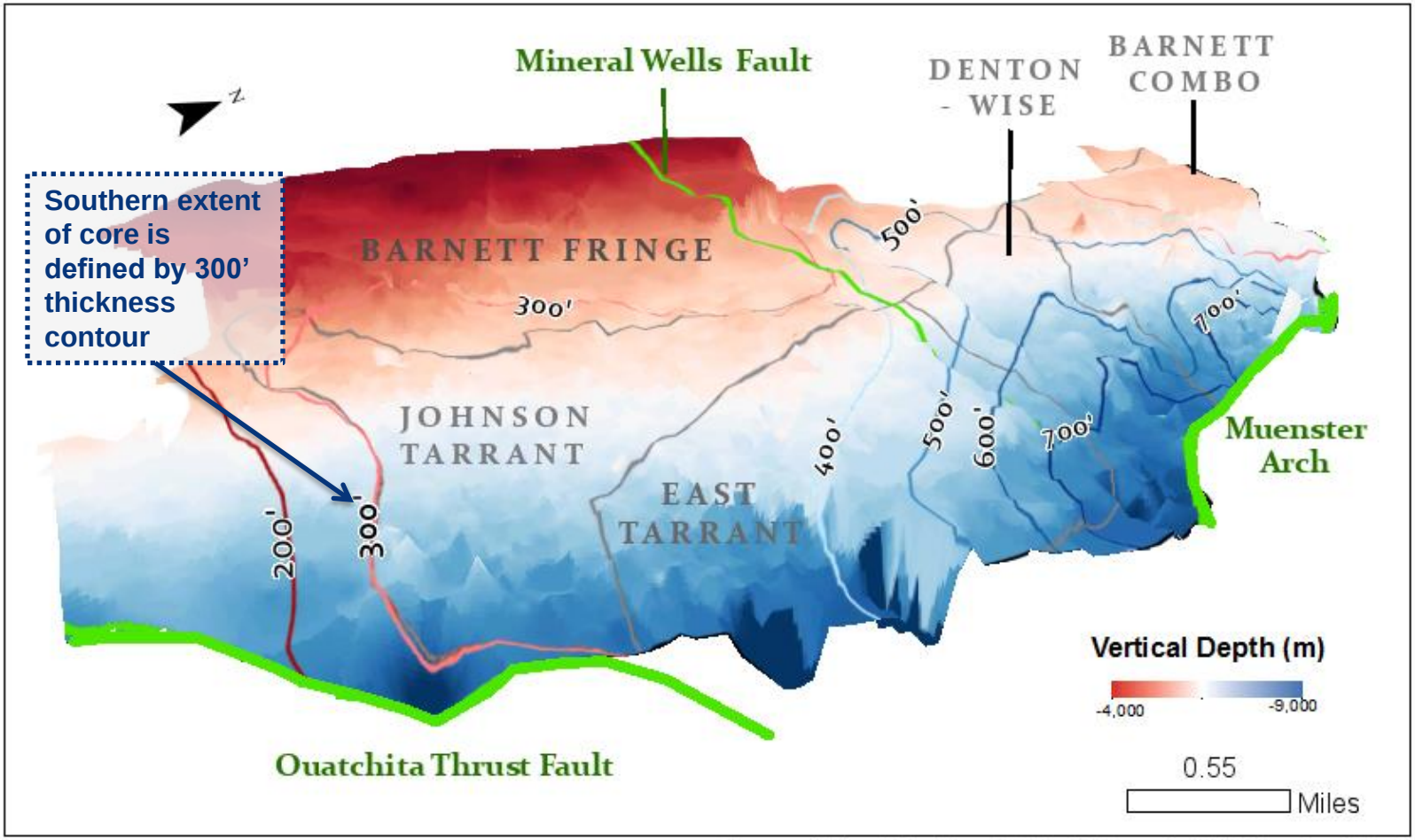
Finalize sub-plays

- Developing risking factor
- Analyze well costs and type curves

Wood Mackenzie
A Verisk Analytics Business

Geology: vertical depth and thickness

Depth and thickness increase to the east defining core area



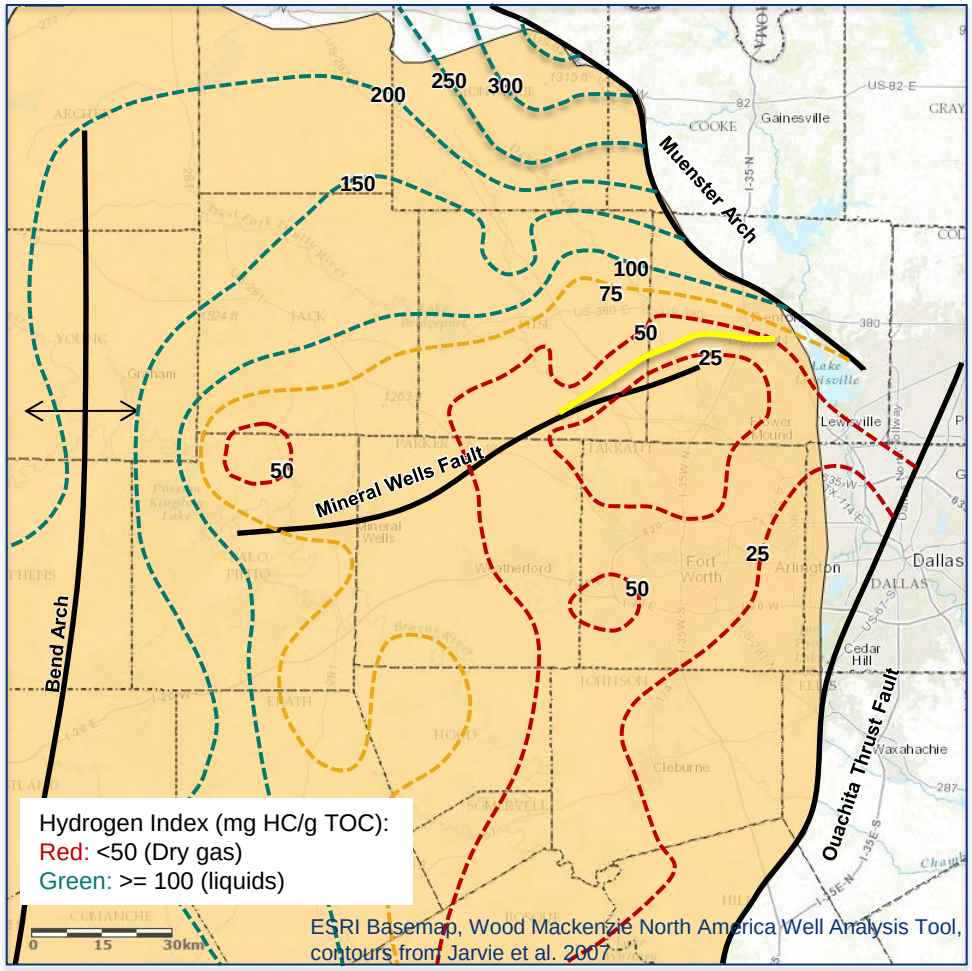
Southern extent of core is defined by 300' thickness contour

Core area limited to east as low pressure and thin Barnett limit productivity in fringe areas

Source: Wood Mackenzie North America Well Analysis tool
Thickness contours from Pollastro et al. 2007

Geology: thermal maturity and fracture barriers

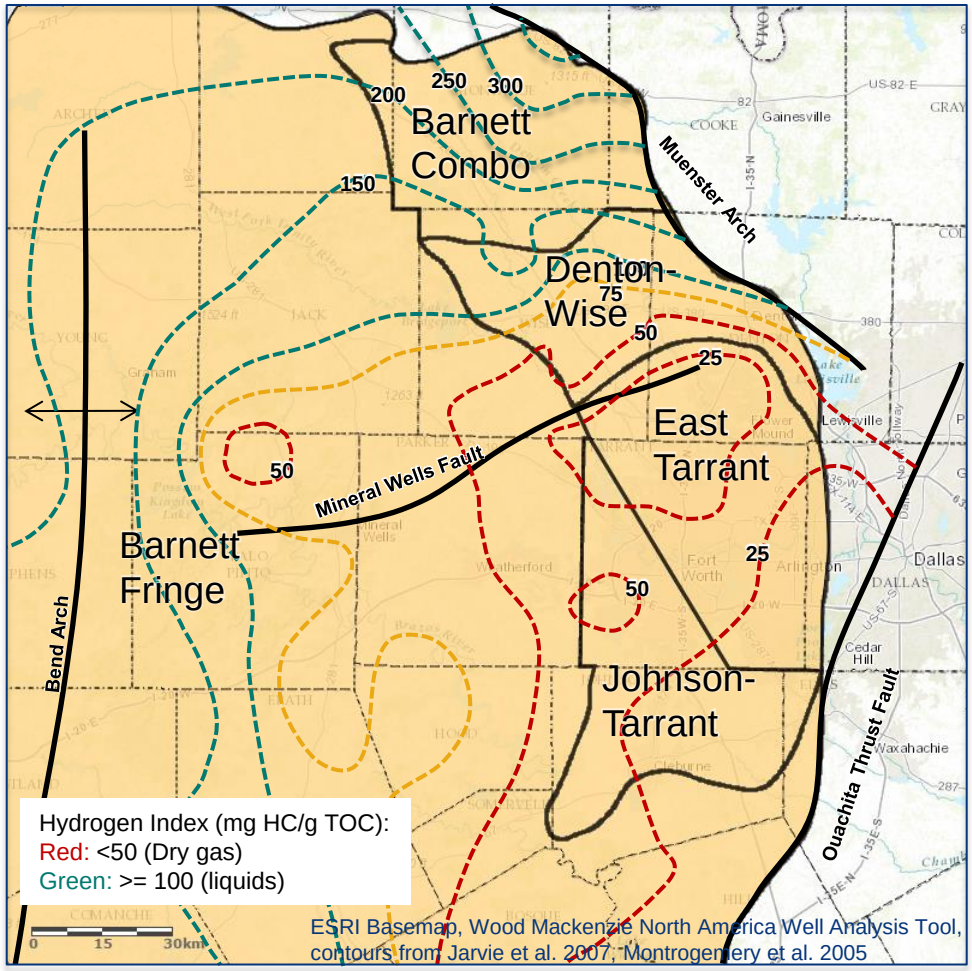
Hydrogen Index constrains dry gas extent



- Thermal Maturity
  - » High HI: liquids generation
  - » Low HI: dry gas generation
- » Helps explain distribution of hydrocarbon type across the play
- » Contours help define boundary between dry gas and wet gas sub-plays

Geology: thermal maturity and fracture barriers

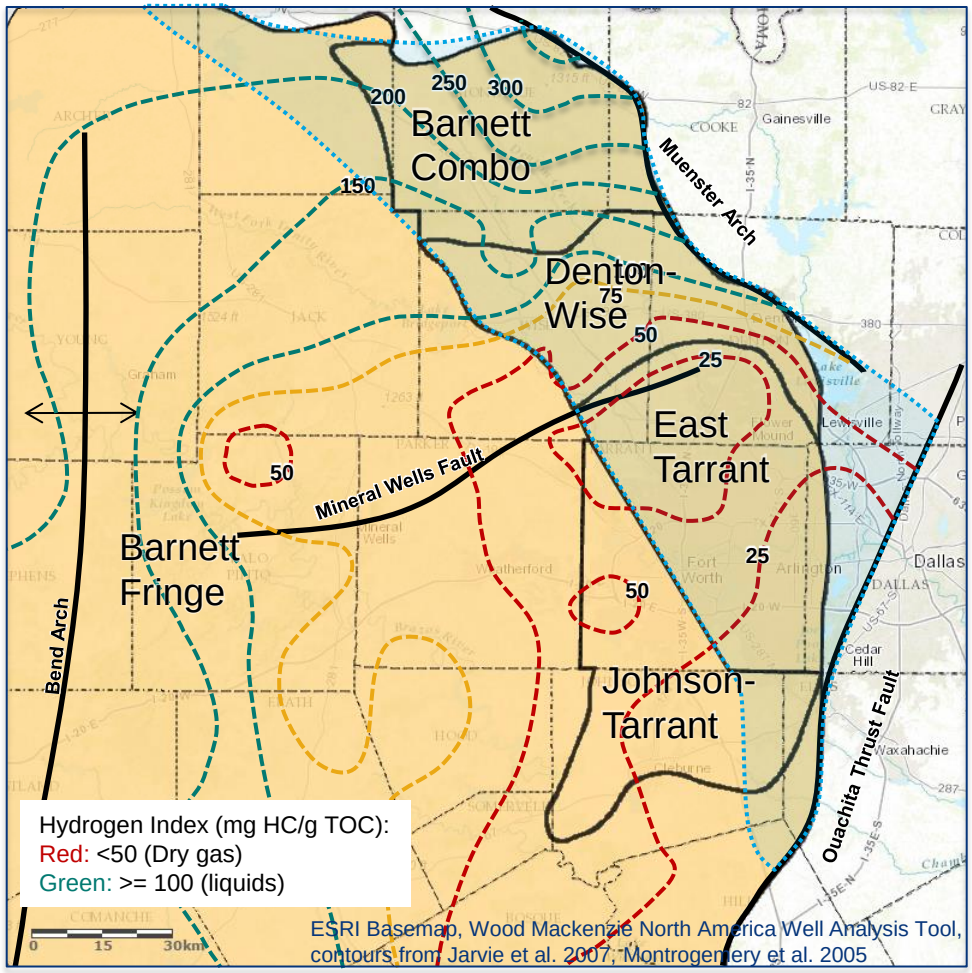
Hydrogen Index constrains dry gas extent



- Thermal Maturity
  - » High HI: liquids generation
  - » Low HI: dry gas generation
- » Helps explain distribution of hydrocarbon type across the play
- » Contours help define boundary between dry gas and wet gas sub-plays

Geology: thermal maturity and fracture barriers

Fracture barrier constrains core and splits dry gas area

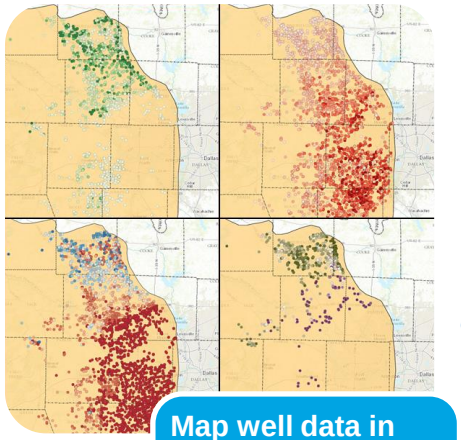


- Thermal Maturity
  - » High HI: liquids generation
  - » Low HI: dry gas generation
  - » Helps explain distribution of hydrocarbon type across the play
  - » Contours help define boundary between dry gas and wet gas sub-plays
- Fracture barrier
  - » Viola-Simpson blocks fractures from water wet Ellenburger group. Shallower declines where barrier exists
  - » Defines western limit of Denton-Wise
  - » Separates dry gas into two sub-plays

Sub-play definition process

Use ArcGIS online and collaboration with internal mapping to define technically based sub-plays

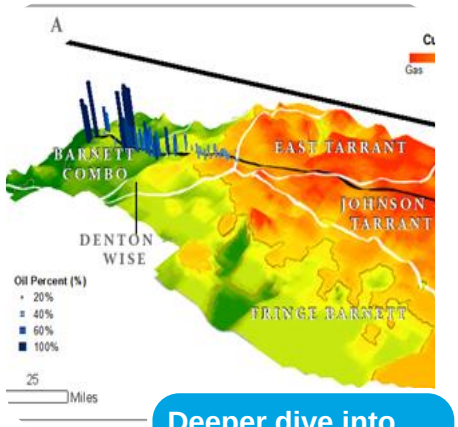
Simple mapping



Map well data in ArcGIS Online

- Productivity
- Percent oil
- API Gravity
- Vertical depth
- Well cost

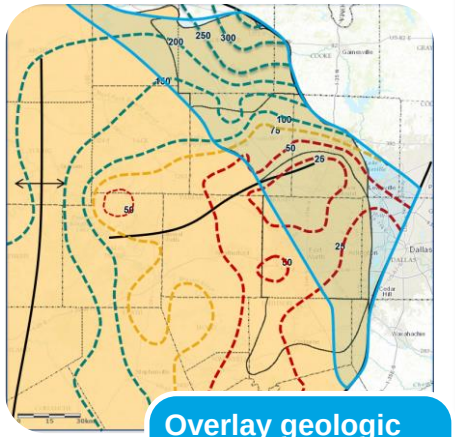
Collaboration with GIS analysts



Deeper dive into data

- Combine datasets
- Create surfaces
- Display in ArcPro

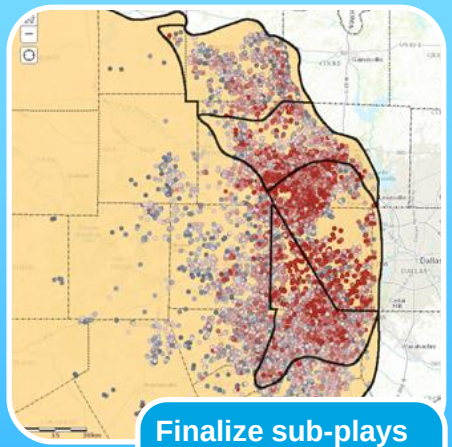
Confirm and explain with geology



Overlay geologic maps

- Vertical depth
- Thickness
- Thermal maturity
- Fracture barriers
- Faults

Finalize sub-plays



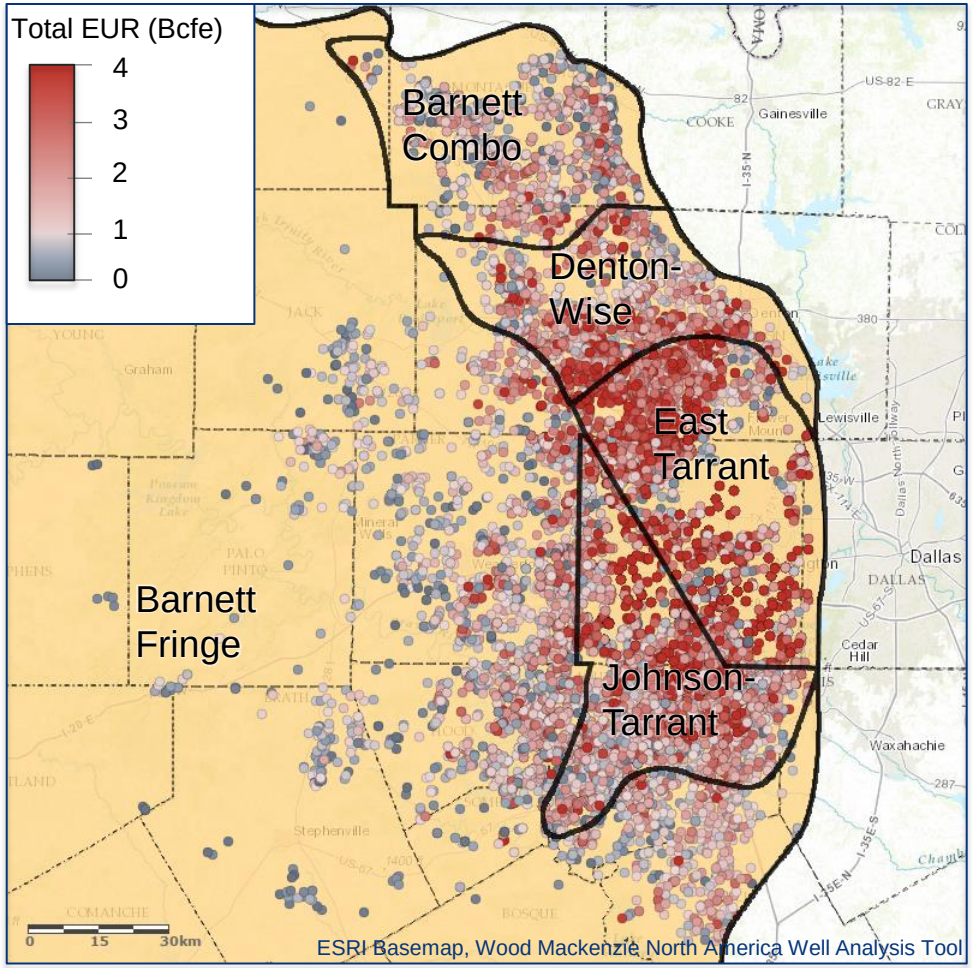
Finalize sub-plays

- Developing risking factor
- Analyze well costs and type curves

Wood Mackenzie
A Verisk Analytics Business

Final sub-plays

Determined that five sub-plays captured the activity and well performance better than three



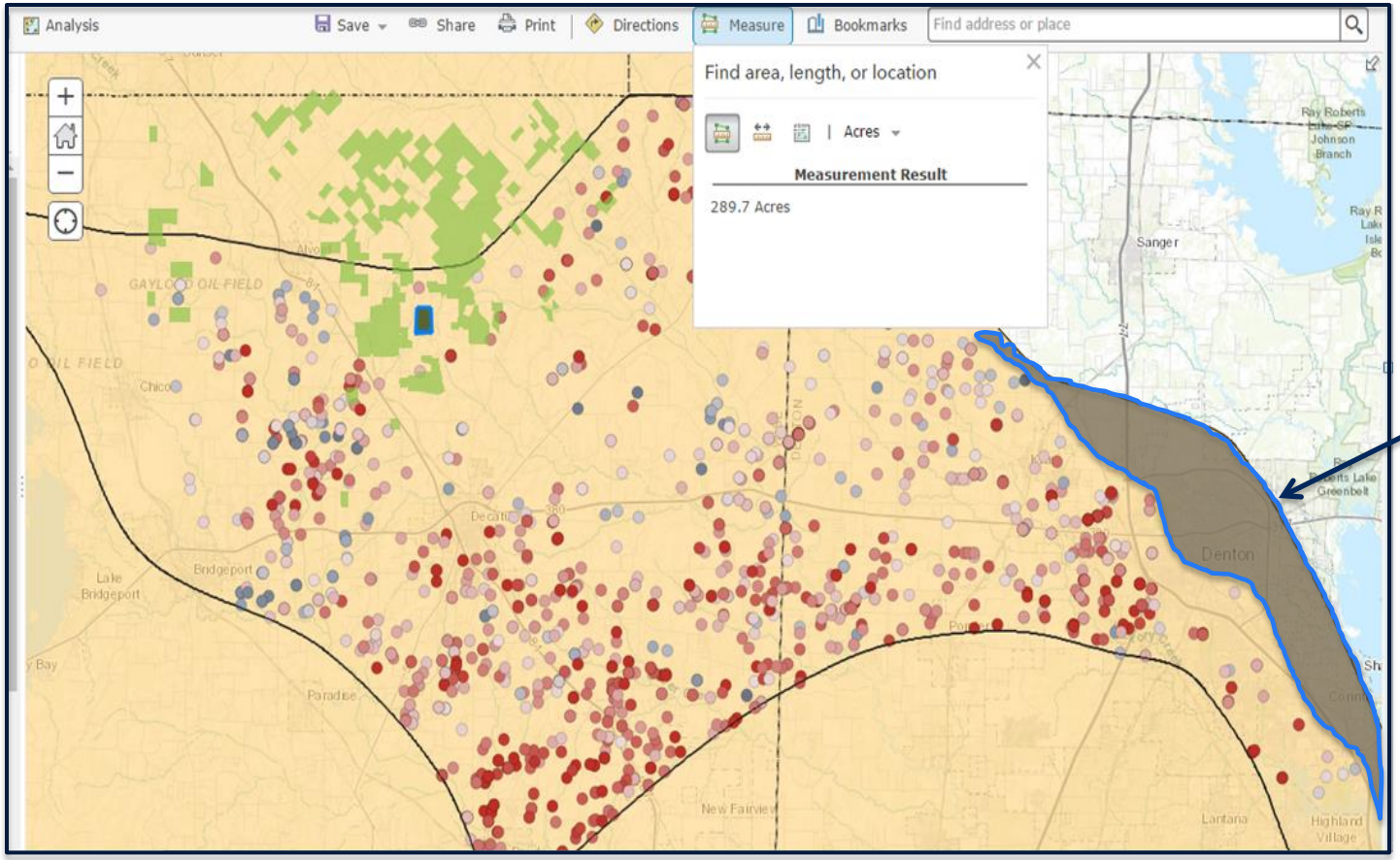
- 5 sub-plays
  - » Barnett Combo (liquids)
  - » Denton-Wise (condensate/wet gas)
  - » East Tarrant (Dry gas core)
  - » Johnson-Tarrant (Dry gas)
  - » Barnett Fringe (low productivity)

- Next Steps:
  - » Develop risking factor
  - » Well costs
  - » Conduct analysis

Risking

Analyze above and below ground risks to determine how much land operators will develop

- Above Ground: Measure areas of national parks, waterways, and areas with no wells or low producing wells. We do not expect most of this area will be developed.

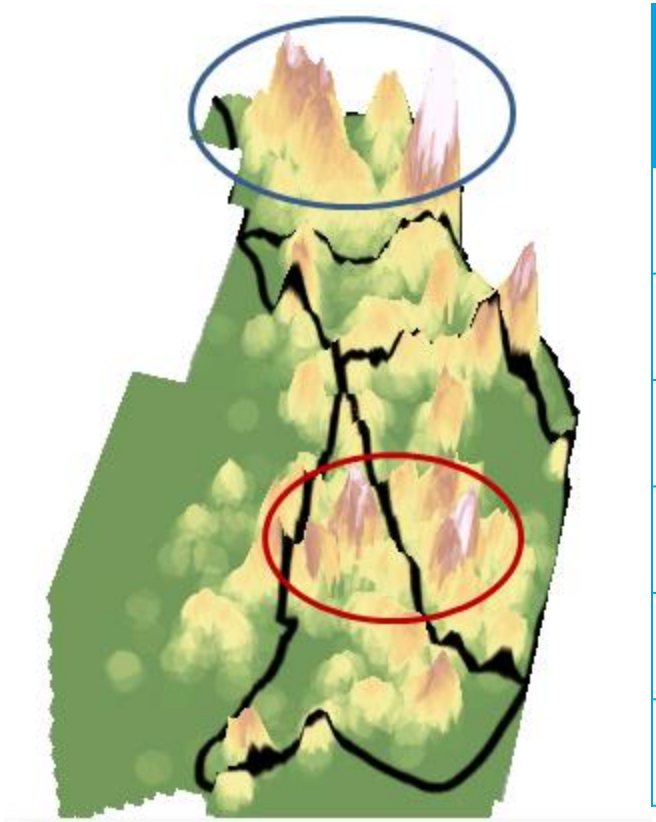


- Below ground: some areas are heavily faulted and may not be drilled. Example:
  - Operators stay away from Ouachita thrust front. Although deep (sufficiently high pressure) and thick, it is heavily faulted, reducing returns.

Well costs visualized across the sub-plays

Well designs vary through sub-plays, but are more consistent among operator positions.

- Well cost
  - » Operator specific
  - » Vertical depth, which is a good proxy for drilling cost, is not on the same trend as hydrocarbon type.

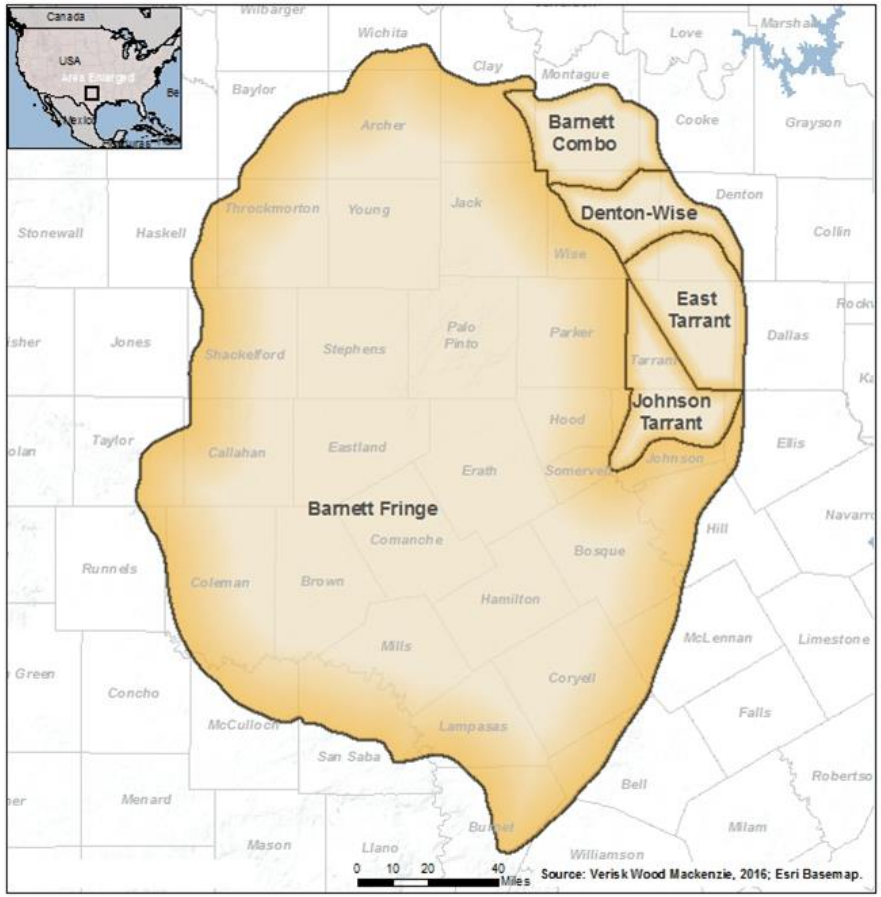


Barnett Combo well cost	$2.8 million
Drill days	11 days
Lateral length	5,000 feet
Measured depth	12,200 feet
Proppant usage	900 lbs/ft
Water usage	1,000 lbs/ft
Frac stages	20 stages

Results

More granular, average valuations help predict value of new entrants' positions.

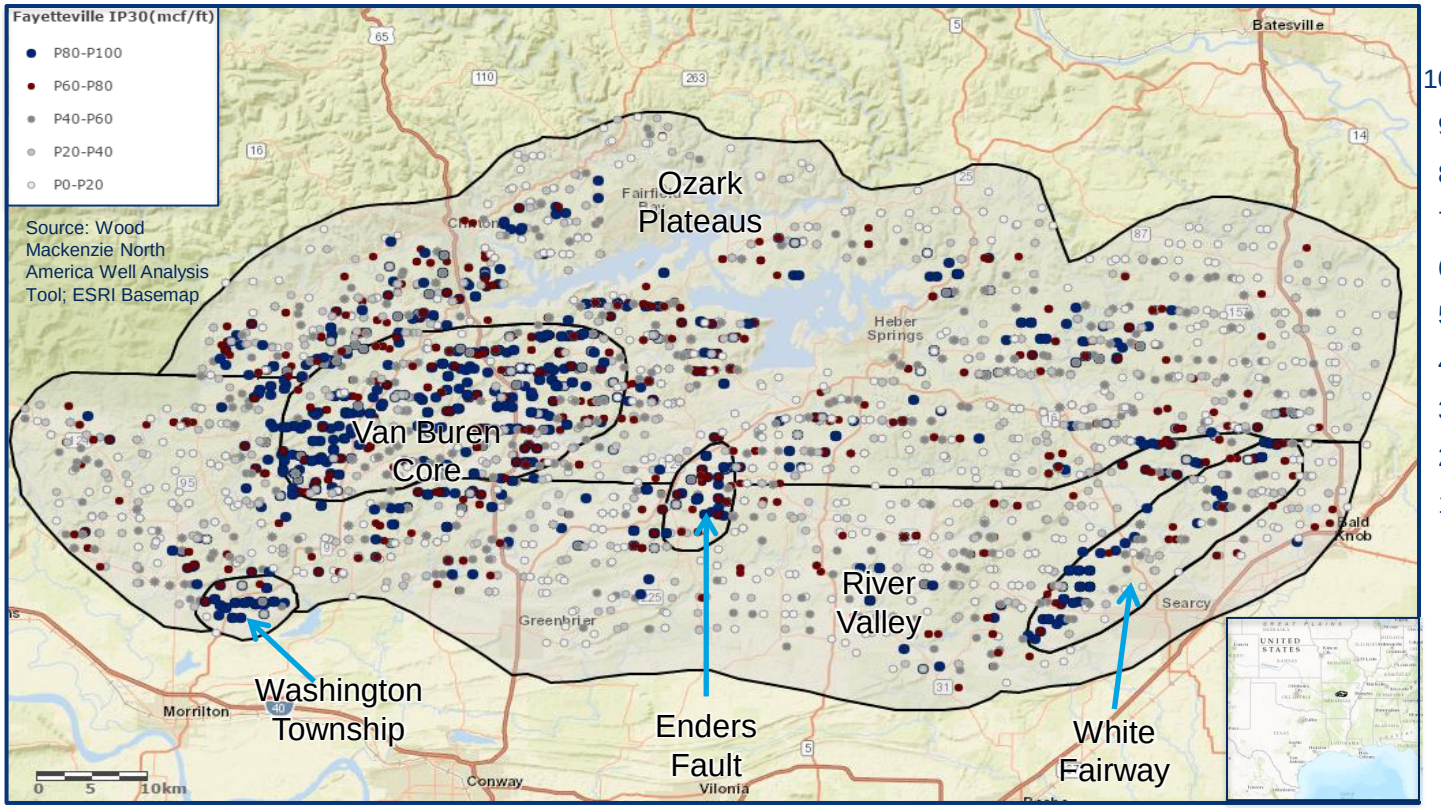
- Breakevens:
  - » East Tarrant: $3.01/mcf
  - » Johnson Tarrant: $3.76/mcf
  - » Denton Wise: $4.22/mcf
  - » Fringe: $6.08/mcf
  - » Combo: $85.52/bbl
- Denton-wise valuation change
  - » No wet gas subplay initially as it was included in dry gas core.
  - » Yet breakevens higher than old "Tier 1" play; this is likely due to lower pressure than areas with peak dry gas generation to the south
- Note: Fayetteville demonstrates very strong results from sub-play breakouts.

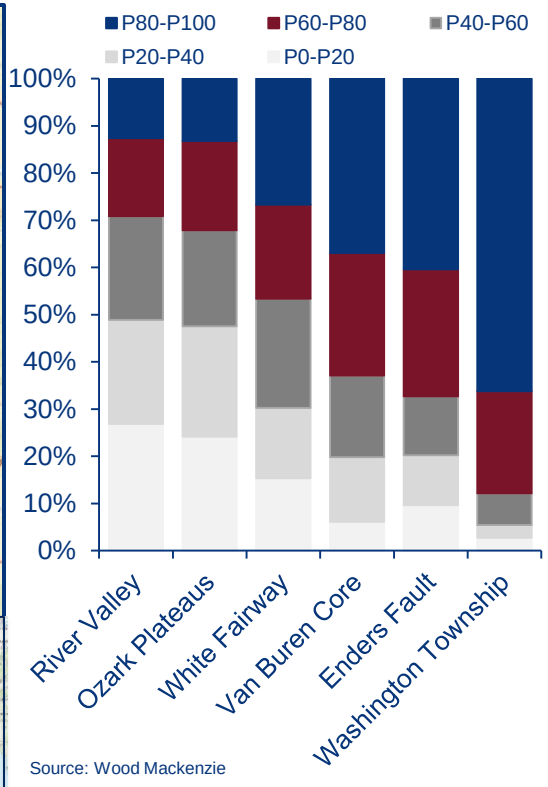


Wood Mackenzie
A Verisk Analytics Business

Other case studies

Fayetteville



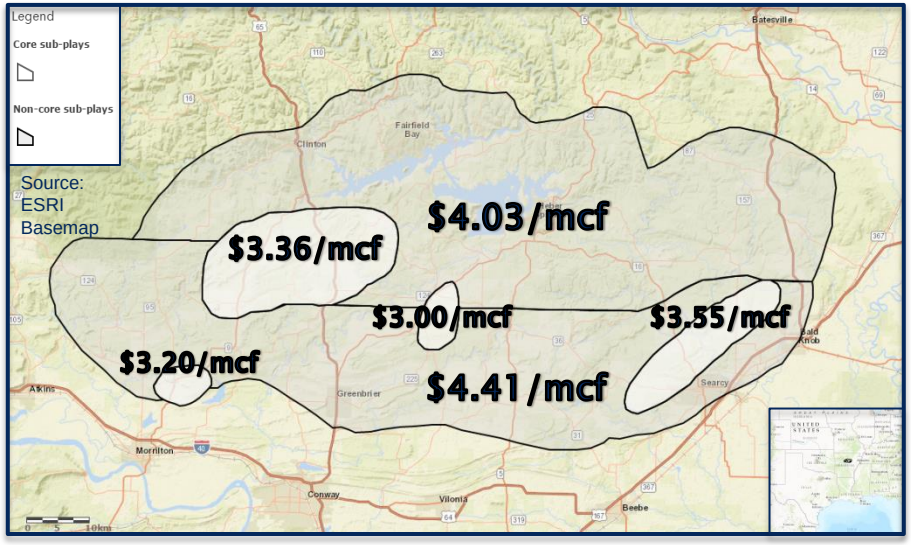


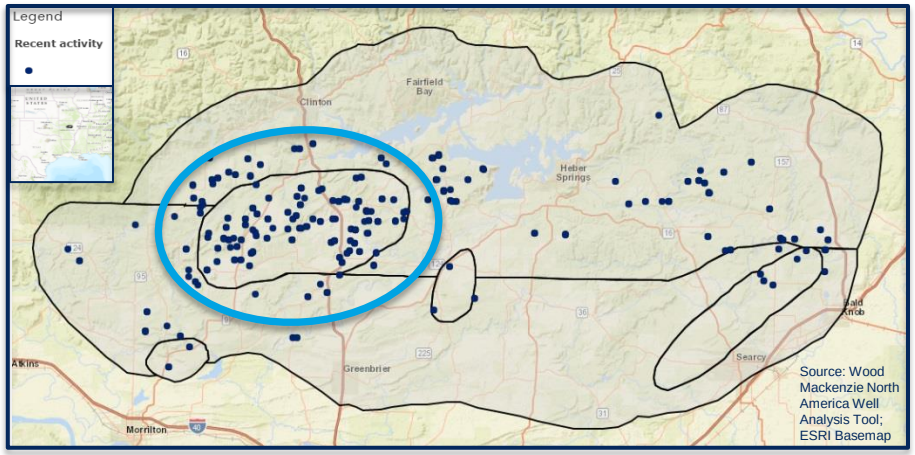
Source: Wood Mackenzie

Here we show top 20% of wells in red and top 40% of wells in red in addition to blue. While operators maintain that the shale is similar throughout the play, there are clearly concentrated areas of top performers.

Results

Running room is limited in core areas.





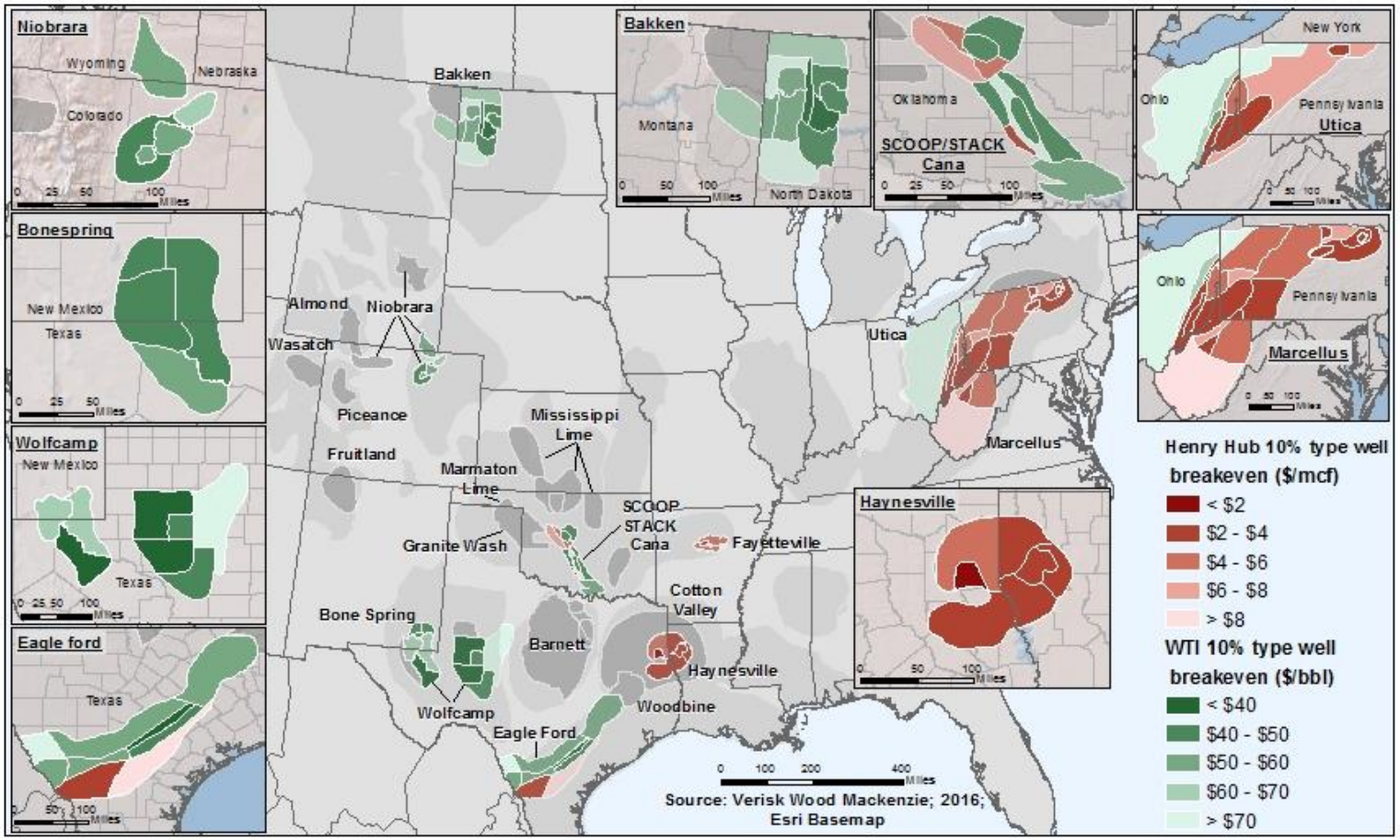
- There are four core areas of the play. Only 7% of remaining location exist in core areas.
- As the play is quite homogenous and performs similarly, well costs are based on vertical depth.
- We were basing valuations on recent activity, which was concentrated in the Van Buren Core.

Fayetteville Operator A	Remaining Locations	Breakeven
One play: Fayetteville	6,500	$3.36/mcf
Core sub-plays: Van Buren Core, Enders Fault, White Fairway and Washington Township	481	$3.07-$3.56/mcf
Non-core sub-plays: Ozark Plateaus and River Valley	5,013	$4.03-$4.39/mcf

Key play coverage across the US Lower 48

Granular, in depth analysis breaking apart the top ten plays into distinct sub-plays

- Bakken/Three Forks
- Eagle Ford
- Delaware Wolfcamp
- Midland Wolfcamp
- Bone Spring
- SCOOP/STACK
- Niobrara
- Haynesville
- Barnett
- Fayetteville



Wood Mackenzie
A Verisk Analytics Business

Conclusion

Wood Mackenzie's GIS Platform

- Building on a corporate decision in 2016 to invest in GIS technology with ESRI, the GIS Platform is now gaining momentum at Wood Mackenzie.
- Geospatial data is central to how Wood Mackenzie performs analysis and generates insight.
- The GIS Platform puts tools and data in to the hands of analysts who can then innovate and evolve ideas.
- Visualization is key to understanding trends and the GIS Platform provides an excellent vehicle to collaborate and share ideas.
- This is beginning to fit into our workflows and feed our analysis, creating a positive outcome for Wood Mackenzie and its clients.