Discoveries from the Updip Expansion of the SCOOP Play*

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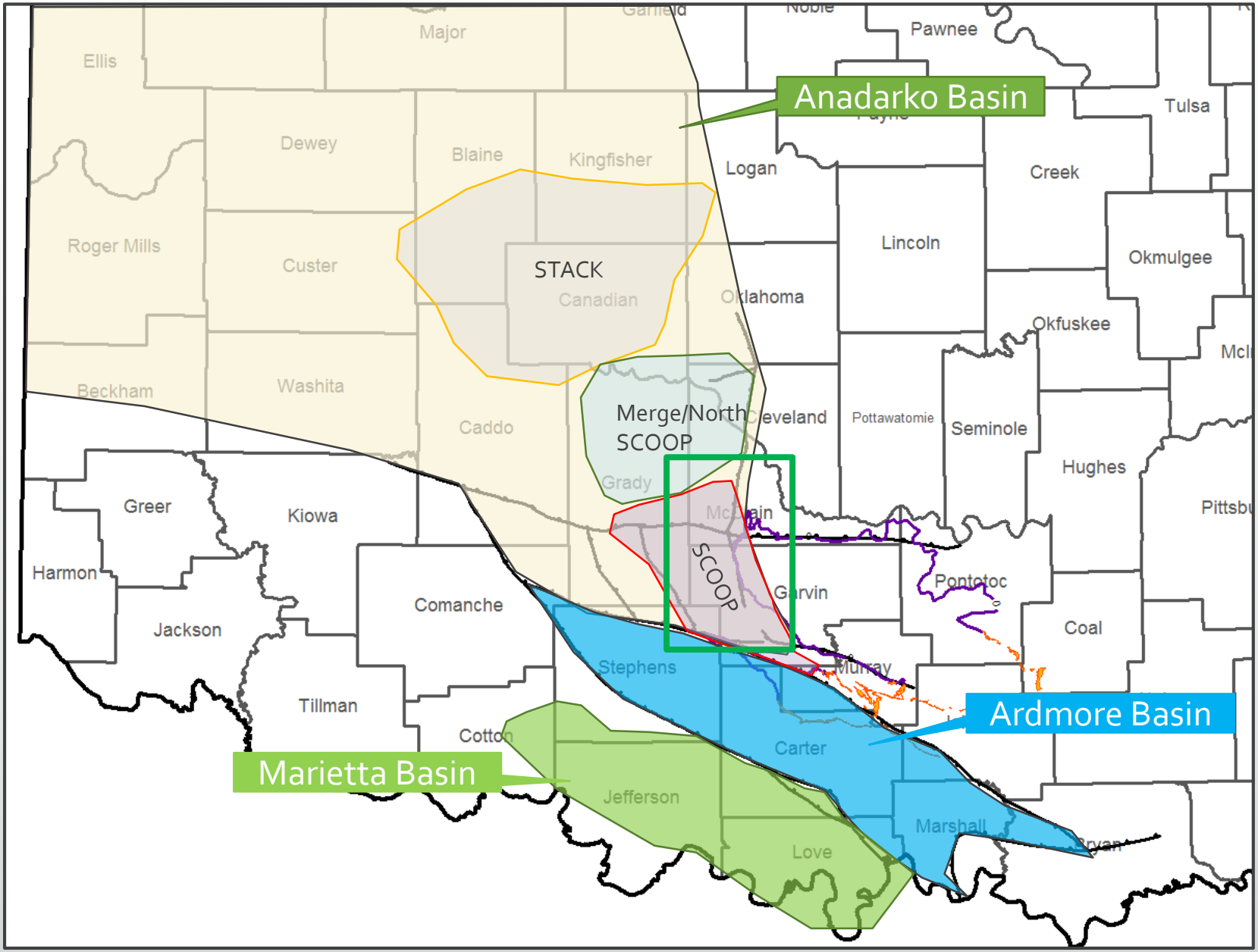
Abstract

Eastward expansion of the SCOOP horizontal play has begun and data is being collected to understand and quantify risk associated with development in and around the Golden Trend Field. The issues of reservoir pressure, product type, reservoir productivity, and fault hazards have been poorly understood in this part of the play. This article presents production, core, log and pressure data collected during a twelve month horizontal drilling program that was designed to test these properties in the Woodford and Springer formations.

Discoveries from the Updip Expansion of the SCOOP Play

AAPG Mid-Continent Section Meeting
Oklahoma City, OK
October 2017

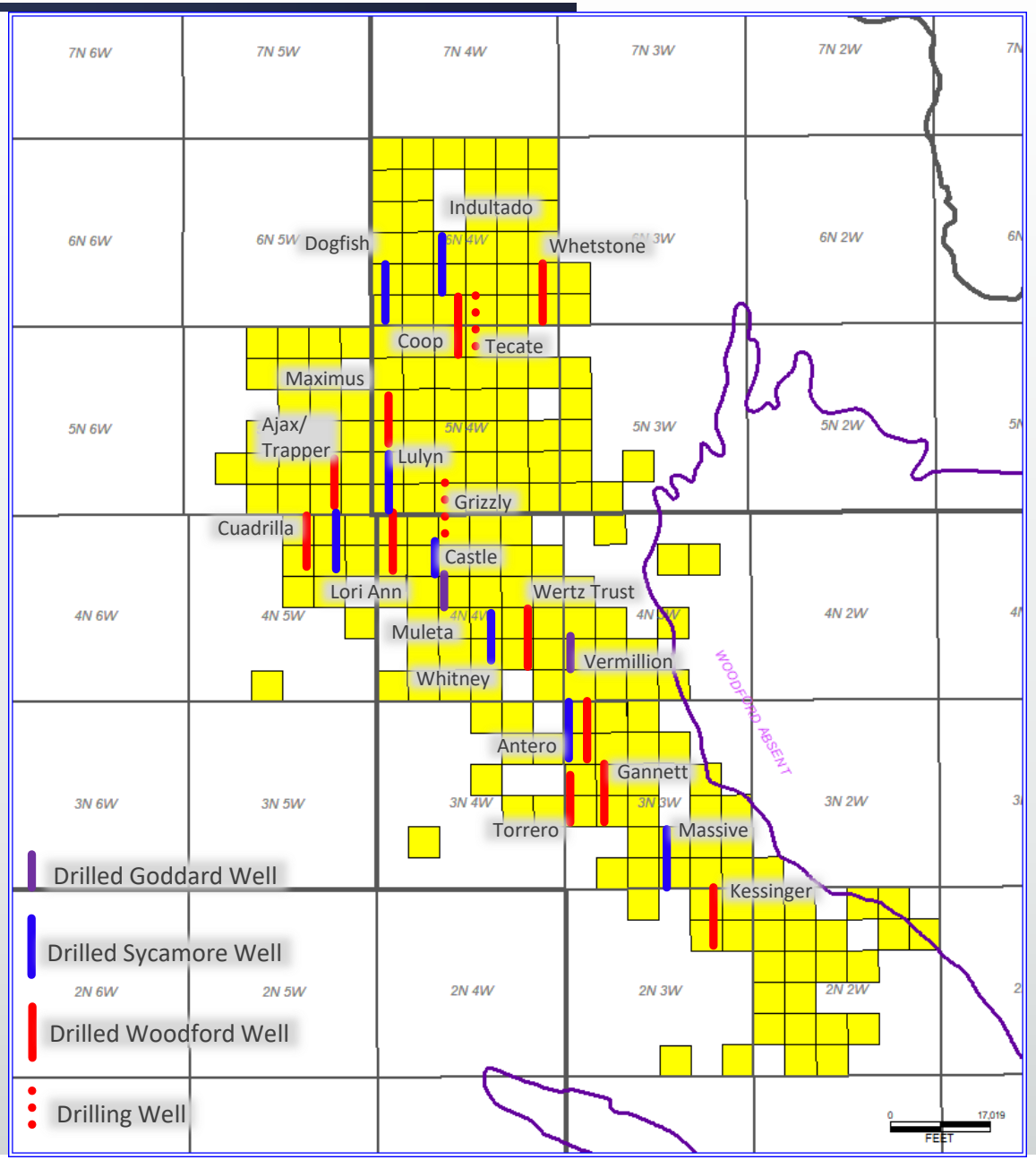
Regional Geologic Setting



Drilling Activity in SCOOP

Outline for today's talk

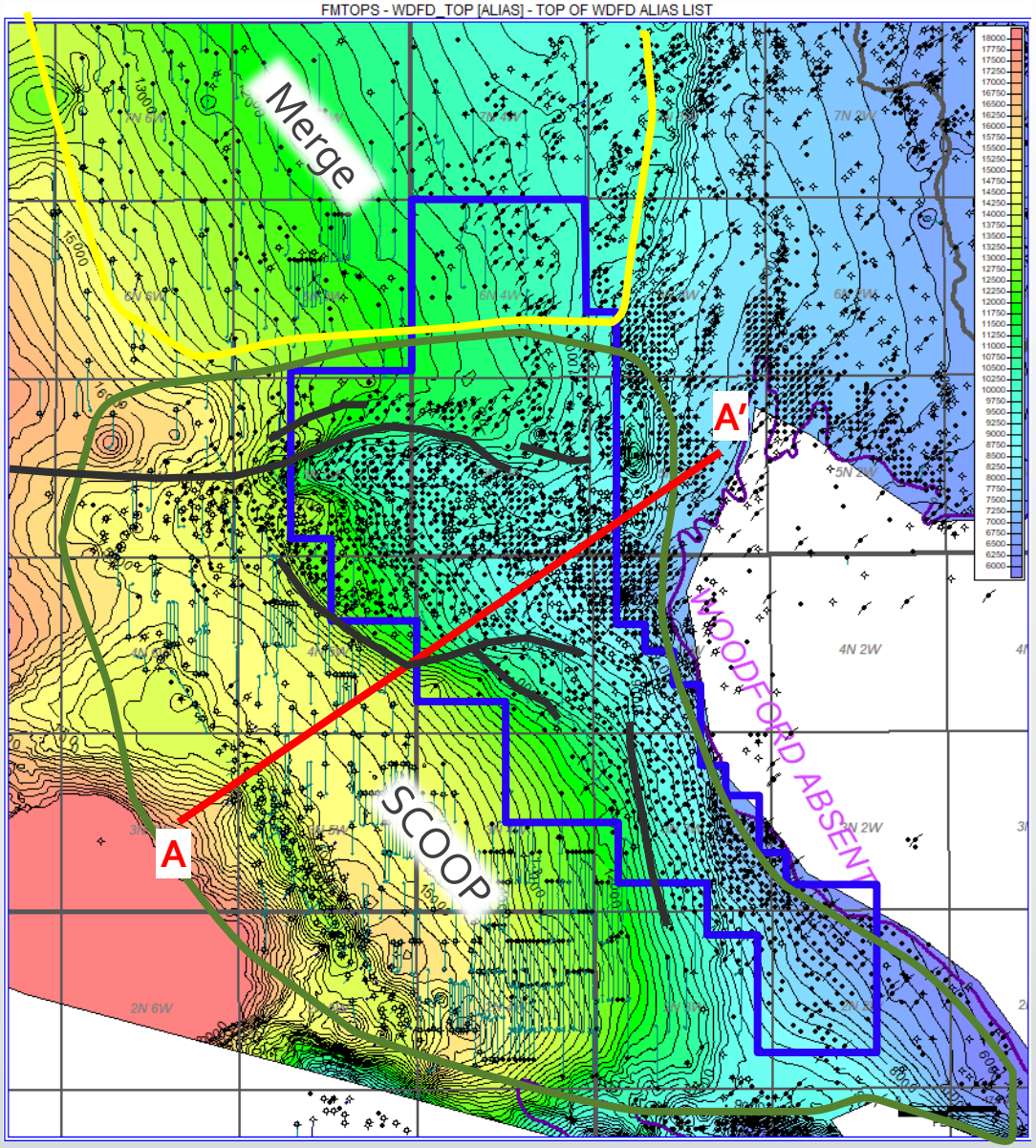
- **Overview of updip SCOOP structural setting**
- **SCOOP area type log**
- **Type log of current horizontal targets**
- **AOI cross section**
- **Interval isopach mapping**
- **Core data overview**
- **Production and fluid analysis overview**



Structural setting for SCOOP Golden Trend

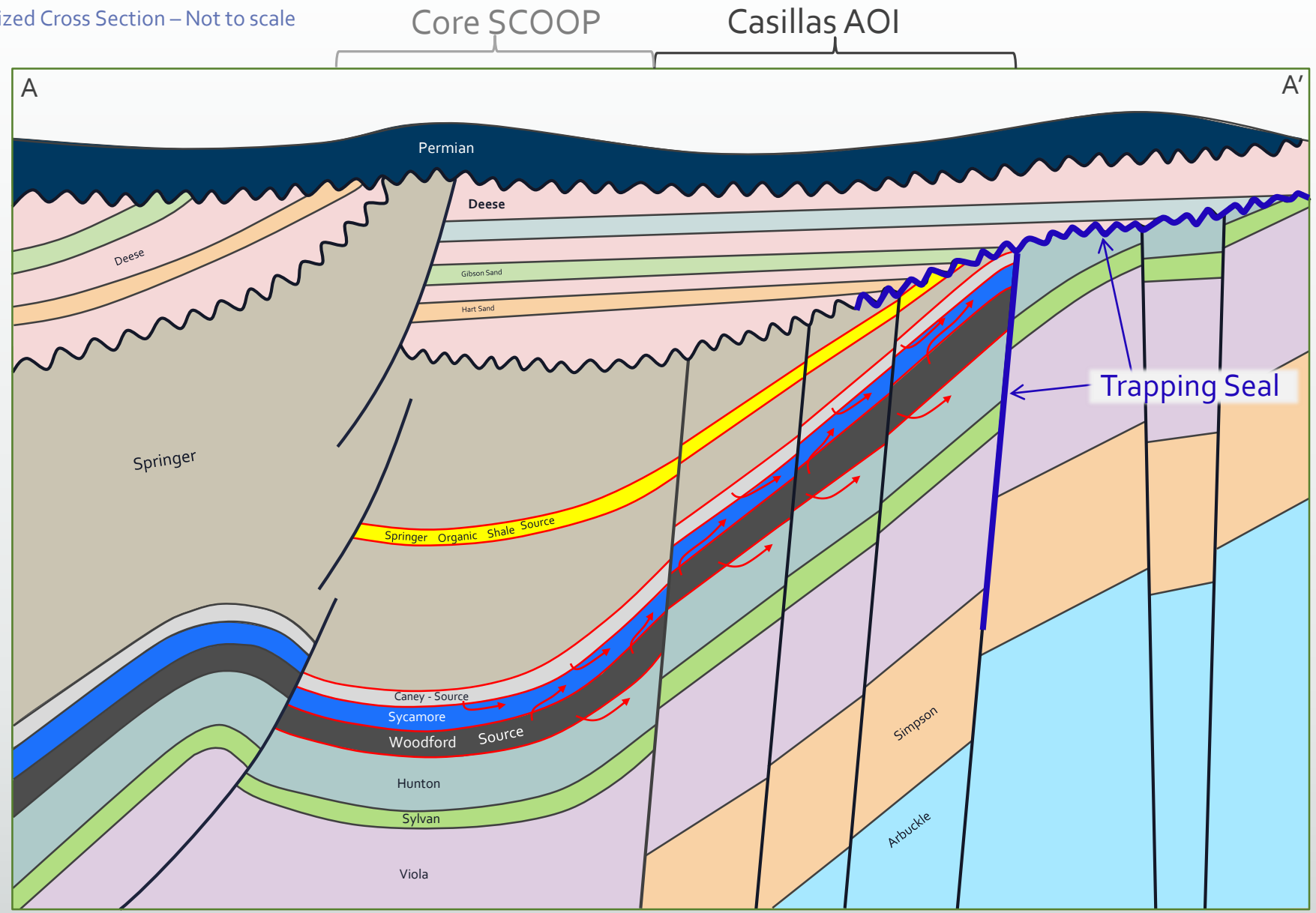
TVD Structure Map on Woodford – Control Shown

- Portion of updip SCOOP play is uplifted by ~E-W faults (overall horst block, faults generalized)
- Depths range from ~8,000' TVD to ~13,000' TVD on the uplifted block
- Core SCOOP play ranges from ~12,000 TVD to ~15,000 TVD to the southwest



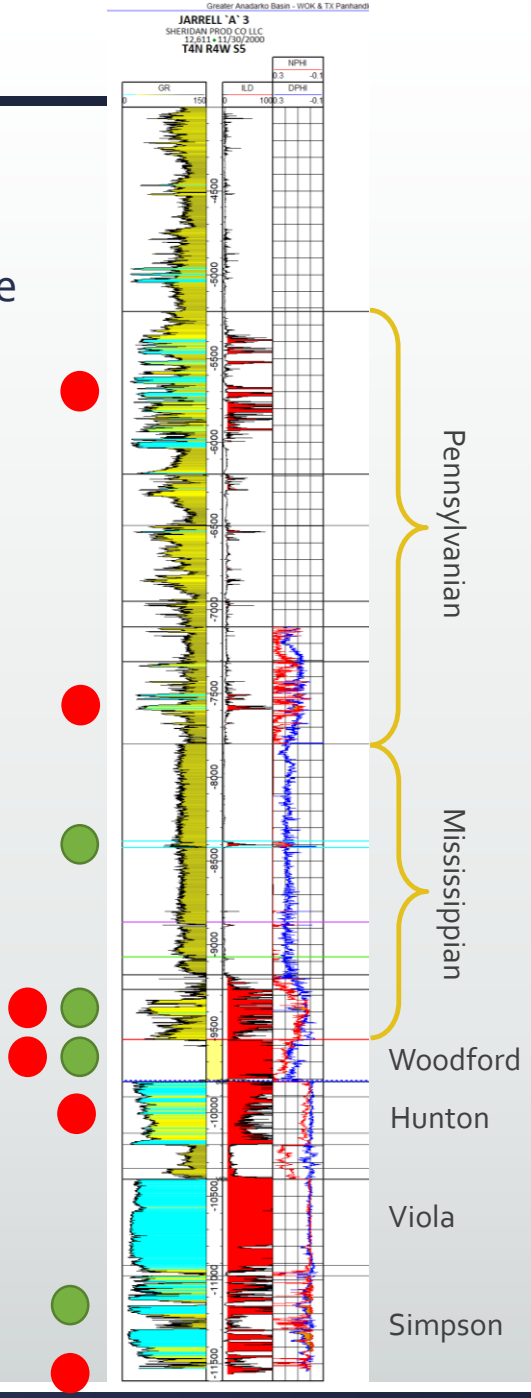
Structural setting for SCOOP Golden Trend

Stylized Cross Section – Not to scale



SCOOP Golden Trend Type Log

- Multiple zones throughout the Golden Trend are productive
  - Pennsylvanian Sequences
    - Douglas/Tonkawa
    - Cherokee Group
  - Mississippian Sequences
    - Goddard (Springer Shale)
    - Sycamore/Meramec
  - Devonian
    - Woodford
  - Silurian/Ordovician
    - Hunton
    - Viola
    - Simpson
    - Arbuckle

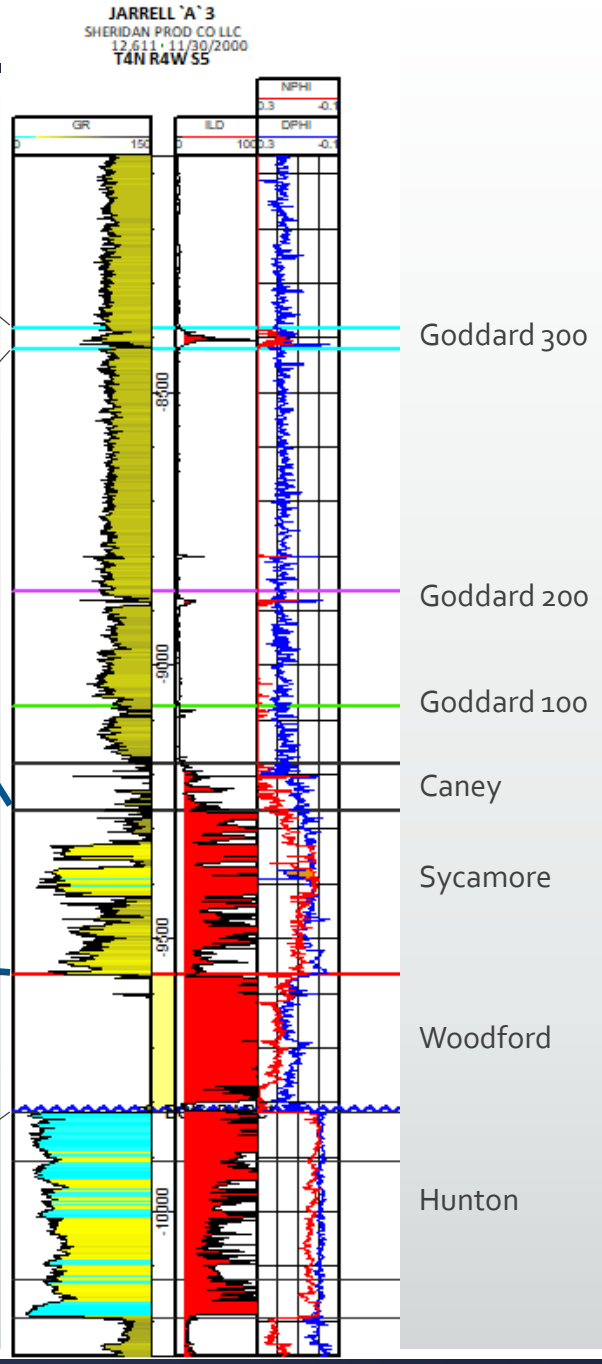


Current Target Type Log

- Goddard 300 – 2 wells drilled
  - Reservoir Analysis:
    - Sidewall Cores – XRD, XRF, Thin Sections, Poro/Perm, TOC/Vro
    - Cuttings – CST/ROT stability analysis, SRA, VRe

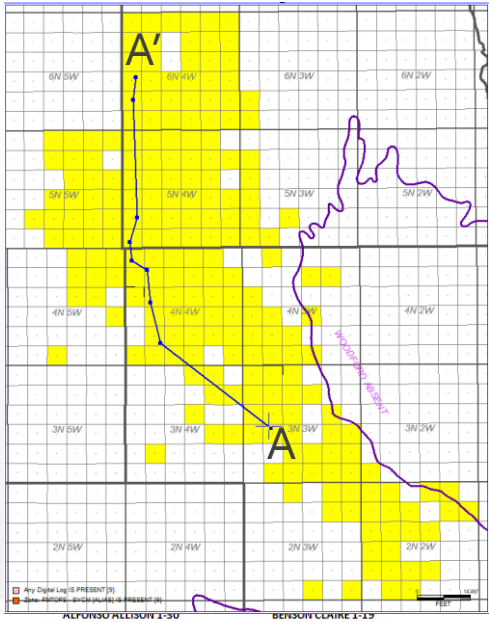
- Sycamore/Meramec – 8 wells drilled, 1 drilling
  - Reservoir Analysis:
    - Whole Core – XRD, XRF, SEM/Thin Sections, Poro/Perm, TOC/Pyrolysis, Saturations, Geomechanics
    - Plugs/Sidewall Cores – XRD, XRF, Thin Sections, Poro/Perm, TOC/Vro
    - Cuttings – CST/ROT stability analysis

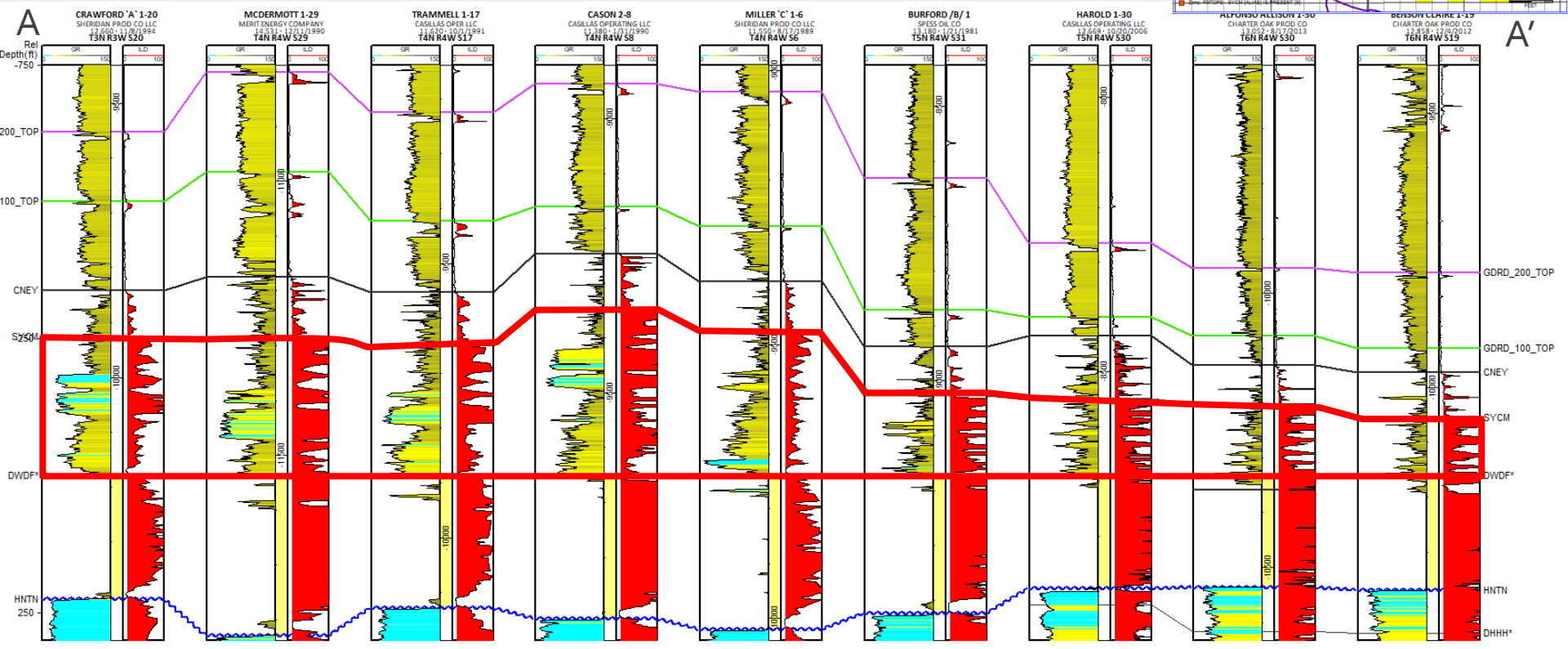
- Woodford – 11 wells drilled, 2 Drilling
  - Reservoir Analysis:
    - Whole core – XRD, XRF, SEM/Thin Sections, Poro/Perm, TOC/Pyrolysis, Saturations, Geomechanics



“Sycamore” Lateral Reservoir Changes

- The Mississippian section throughout this area shows significant lateral facies changes
- Section to south made up of shale (A), interbedded silts (B), and shale (C)
- Section to north made up mainly shales, with very little siltstone

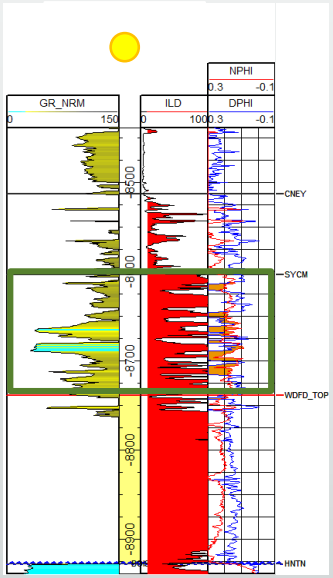


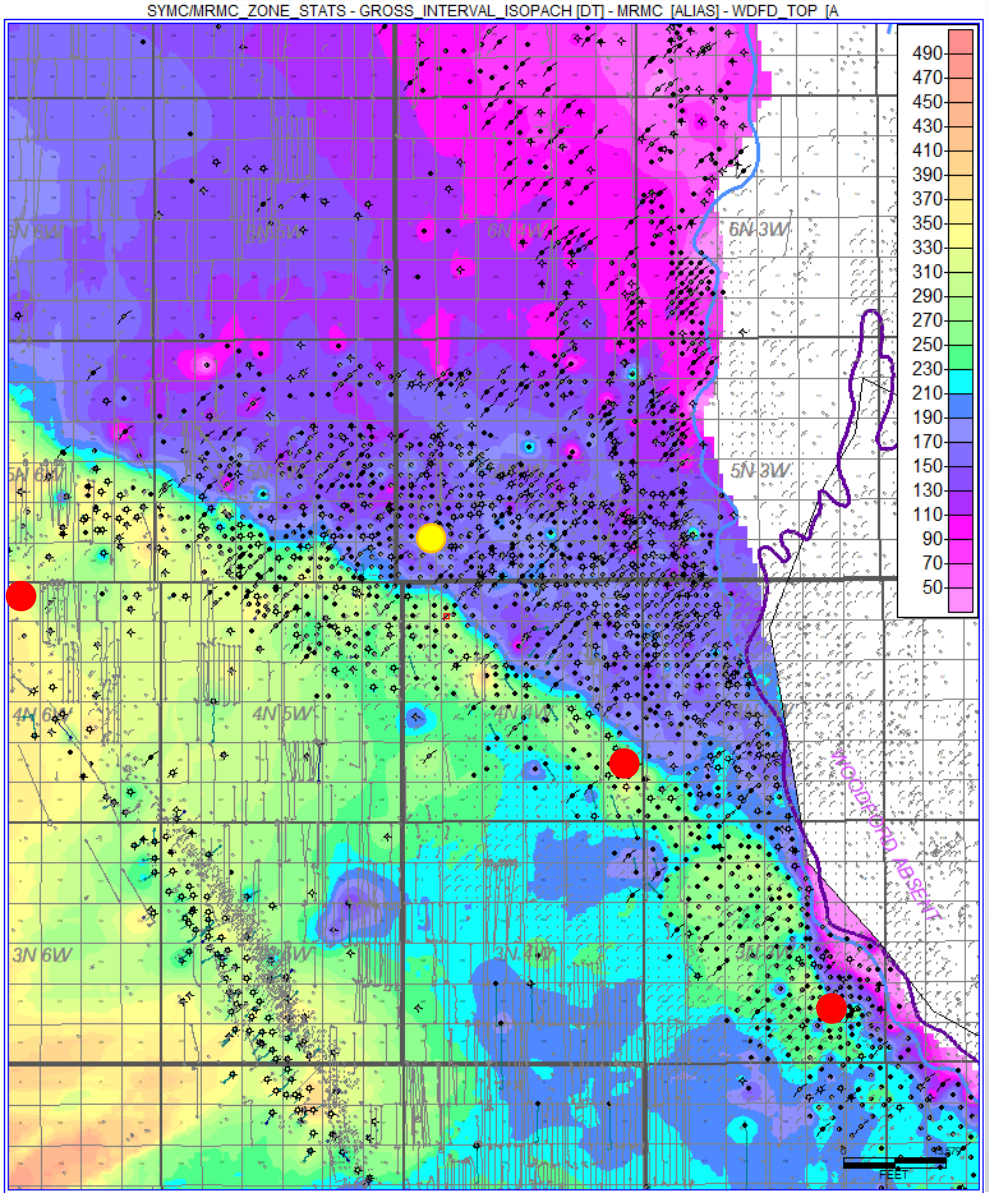


Sycamore Gross Isopach Map – With Core Control Map

- Gross isopach over Sycamore section shows a rapid thinning as you go from SW to NE
- Thick NW SE trend closely correlates with section where major lateral facies change occurs (middle siltstone package present in SW vs not present to NE)

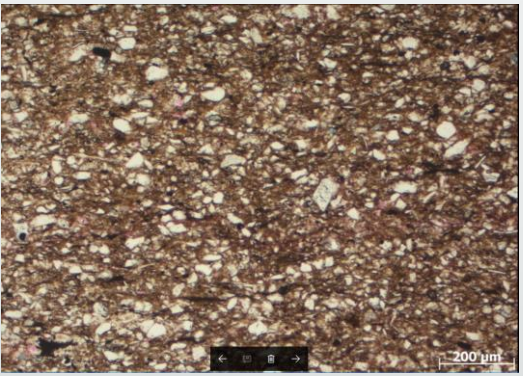
- Whole Core Data
- Plug Data

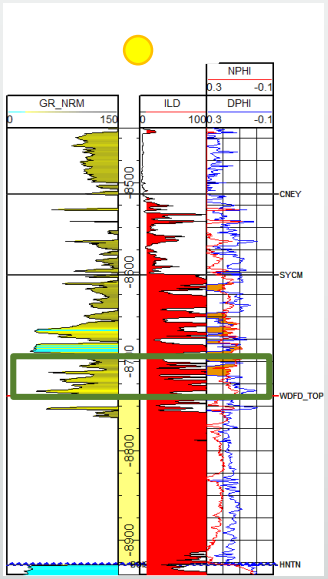




Sycamore "A" Interval Isopach Map

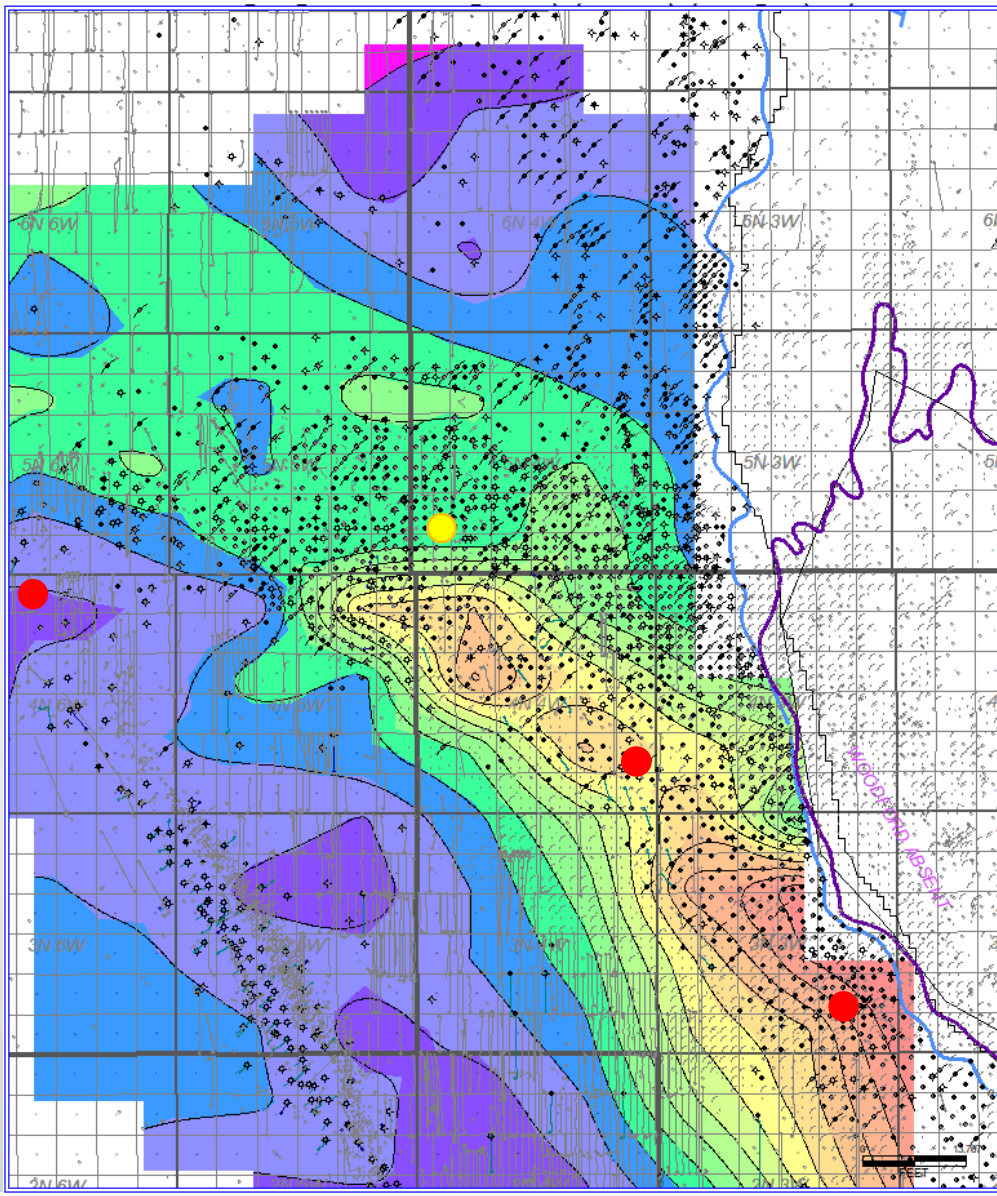
- Lower Sycamore isopach shows similar NW-SE trending thick
- Section thins to the NE and SW
- Average porosity: 8-9 %
- Average k: ~95 µD (PDP)
- 49% Q, 7% Ca, 29% Cl





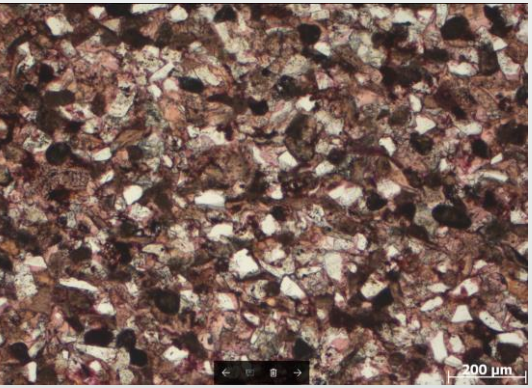
Whole Core Data

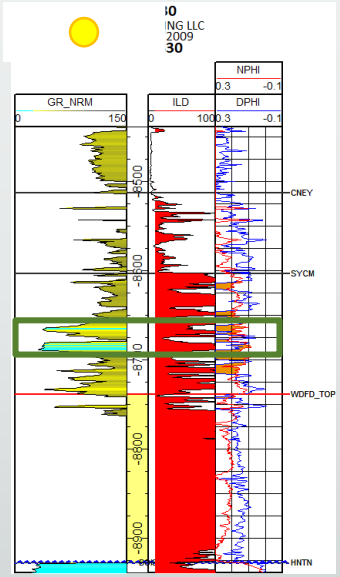
Plug Data

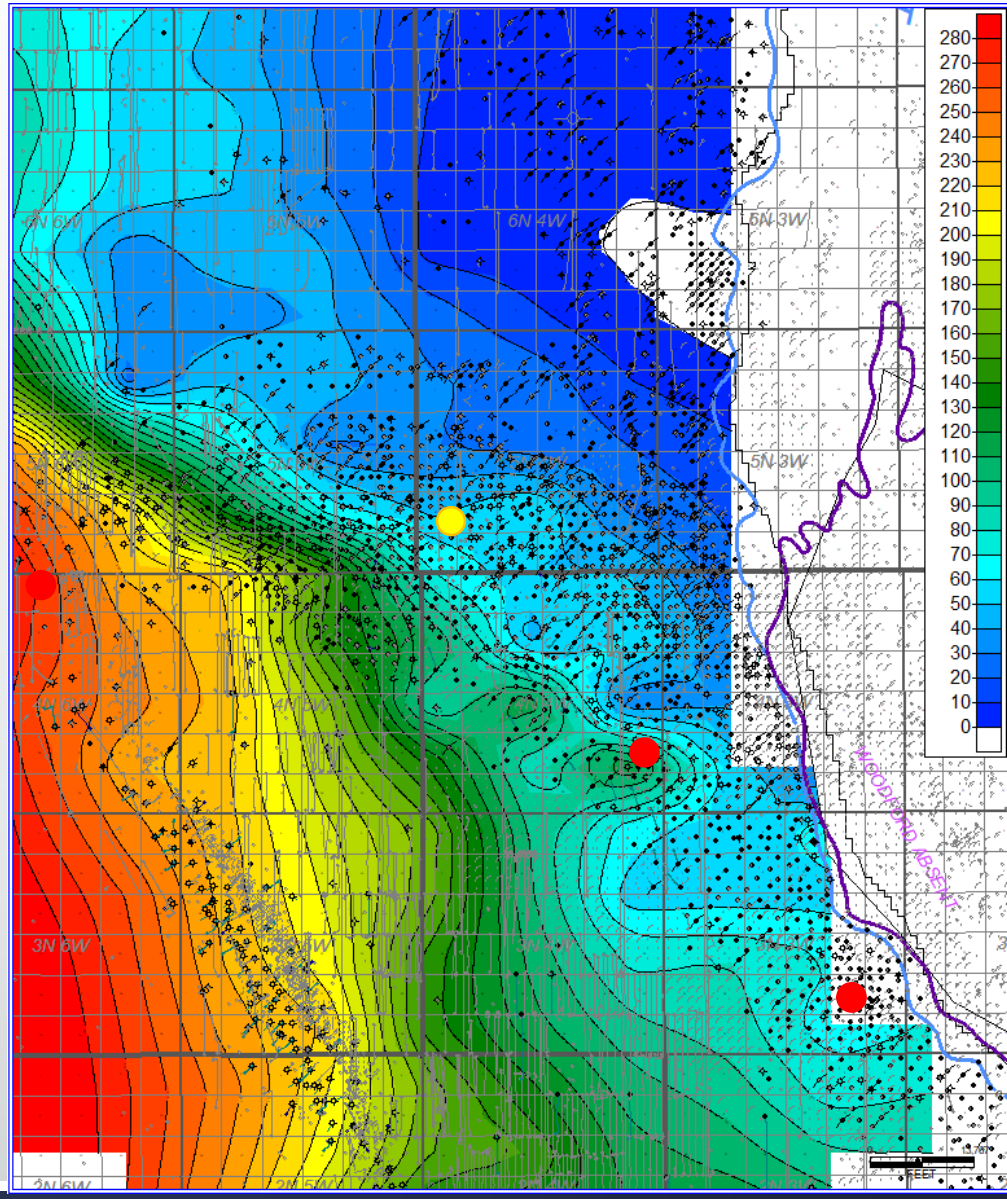


Sycamore "B" Interval Isopach Map

- Middle Sycamore isopach map shows overall thinning to the NE, as cleaner siltstones thin and disappear
- Average porosity: 5%
- Average k: ~4 µD (PDP)
- 37% Q, 24% Ca, 20% Cl





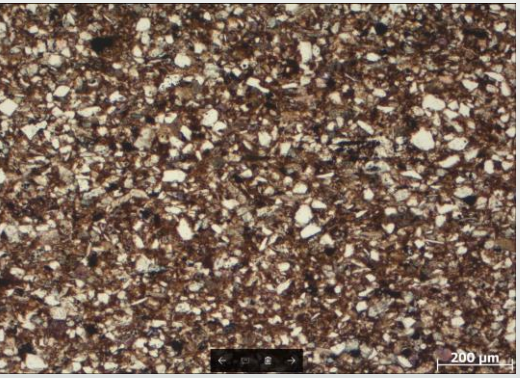


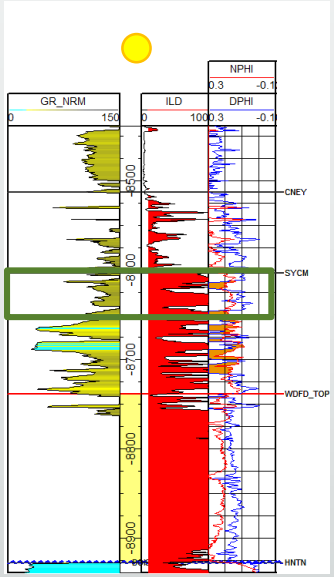
Whole Core Data

Plug Data

Sycamore "C" Interval Isopach Map

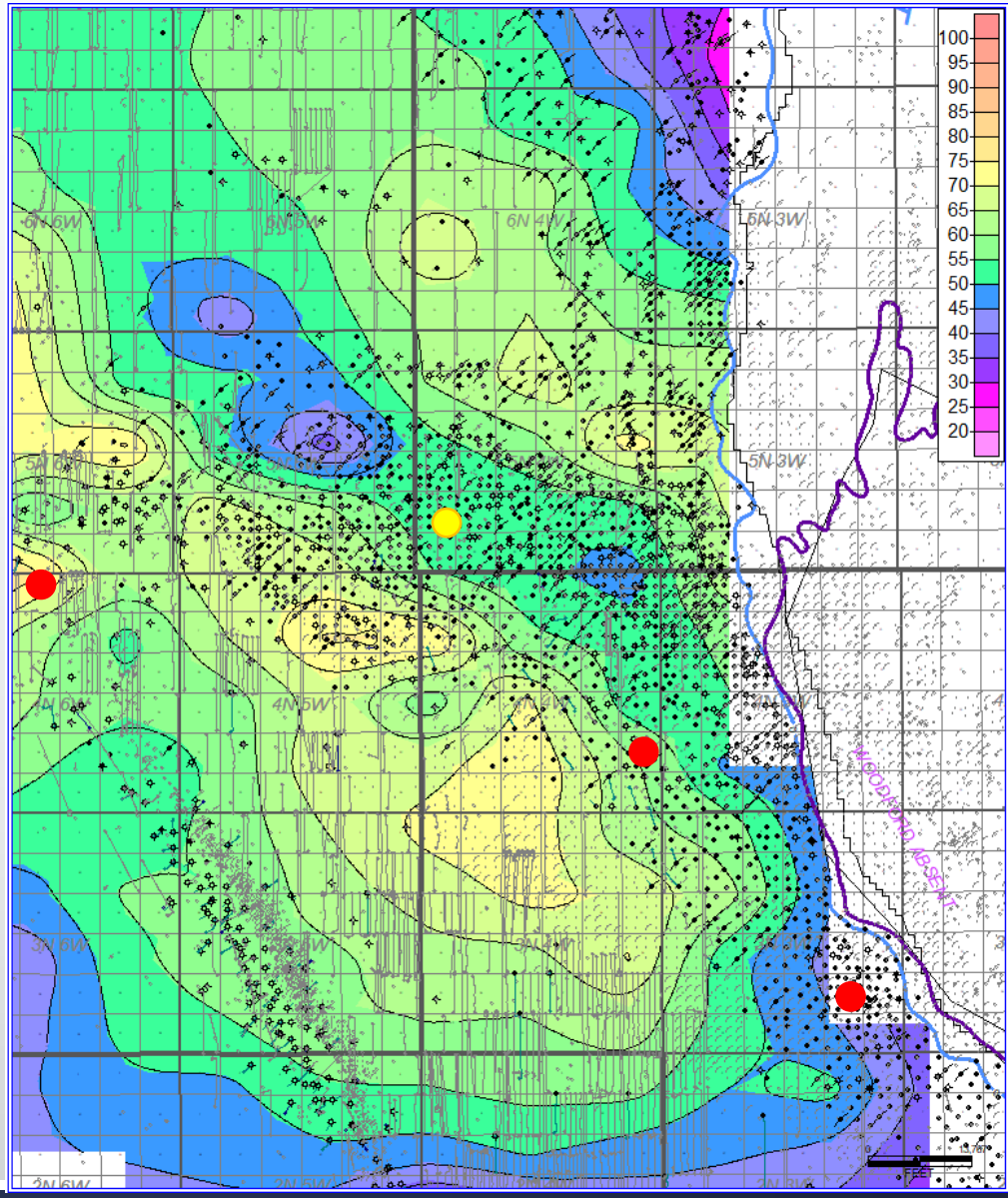
- Upper Sycamore seems to be the most consistent and mappable portion of the section
- Overall thickness variations are smaller than other portions of the section
- Average porosity: 4-5%
- Average k: 100-150 nD (PDP)
- 43% Q, 8% Ca, 29% Cl





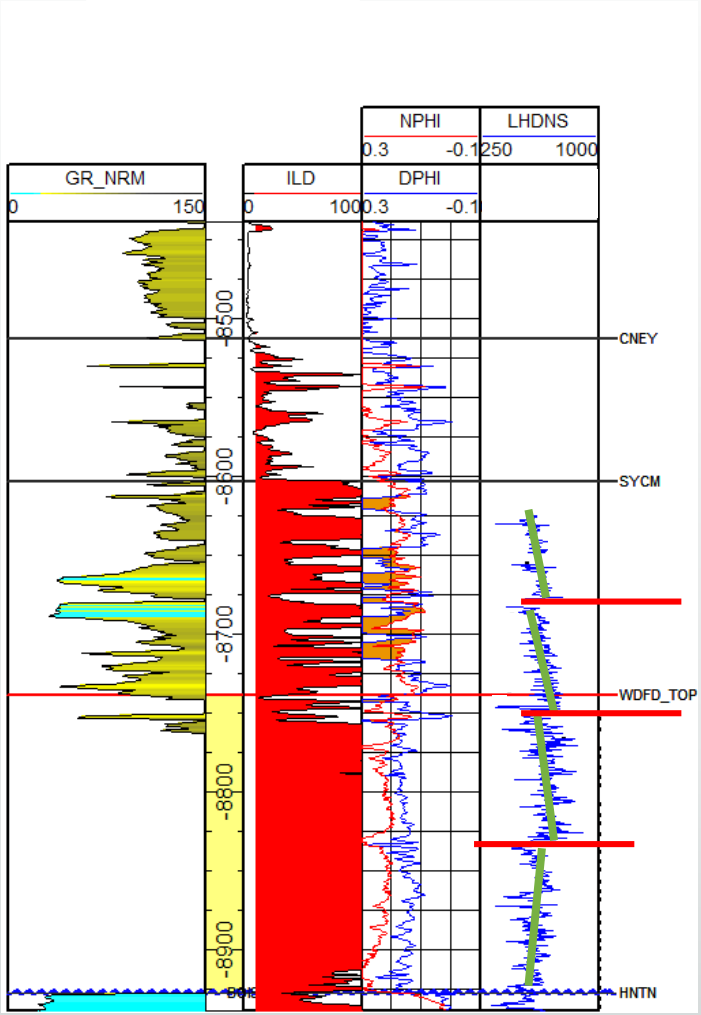
Whole Core Data

Plug Data



Sycamore TOC and Geomechanical data – Multiple Landing Zones

- TOC data from core plugs throughout the Sycamore show source rock potential
  - Upper Sycamore averages ~3.5% TOC
  - Middle Sycamore averages <1% TOC
  - Lower Sycamore averages ~1-2% TOC
- Maturity average - ~0.8-0.9 Vre
- Relative brittleness testing was completed using a mini-rebound hammer
  - Sycamore section has a "natural break" in trend near the middle of the section, with another break present near the top of the Woodford, and middle Woodford
  - In the Woodford, these breaks correlate to the "Upper" and "Lower" drilling targets
  - If the same applies to the Sycamore, multiple landing zones may be present within the section
    - Frac barriers (or baffles) may be limiting completion efficiencies



Producing Wells in Sycamore Section

Sycamore Gross Isopach Map

Sycamore A

Sycamore C

Sycamore A/C (B not Present

CLR- Pudge
IP30: **95** bopd, **10.3** mmcfd
EUR: **120** mbo, **13.7** bcf

NFX- Wendling
IP30: **920** bopd, **1.05** mmcfd
EUR: **679** mbo, **1.5** bcf

MRO – Winter Creek (flowback)
553 bopd, **2.5** mmcfd (14 day avg)

CPRP- Stella - Drilling

CLR- Ryan Express
IP30: **145** bopd, **6** mmcfd
EUR: **235** mbo, **13.4** bcf

CPRP- Dogfish- WOC

CPRP- Indultado
IP30: **751** bopd, **.9** mmcfd
EUR: **1,070** mbo, **2.2** bcf

CPRP- Lulyn
IP30: **240** bopd, **4.7** mmcfd
EUR: **85** mbo, **5.7** bcf

Citizen- Despain
IP30: **131** bopd, **3.7** mmcfd
EUR: **33** mbo, **4.2** bcf

Ward- Lynda
IP30: **748** bopd, **15.2** mmcfd
EUR: **380** mbo, **18.5** bcf

CPRP- Castle
IP30: **536** bopd, **3.6** mcfd
EUR: **225** mbo, **5** bcf

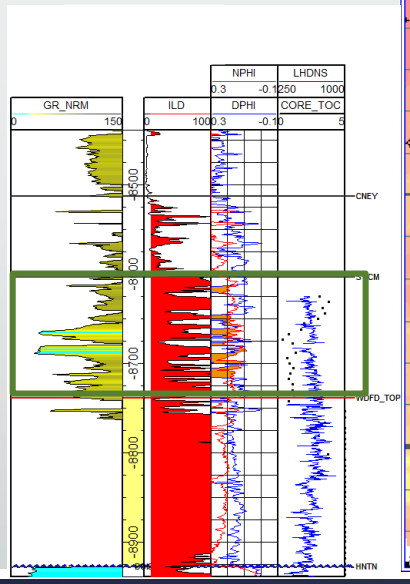
CPRP- Trapper (flowback)
370 bopd, **2.7** mmcfd

Citizen- Branch (flowback)
316 bopd, **2.1** mmcfd (14 day average)

CPRP- Whitney
IP30: **1091** bopd, **2.5** mmcfd
EUR: **645** mbo, **5.1** bcf

CPRP- Antero
IP30: **735** bopd, **2.9** mmcfd
EUR: **420** mbo, **6.6** bcf

CPRP- Massive- WOC



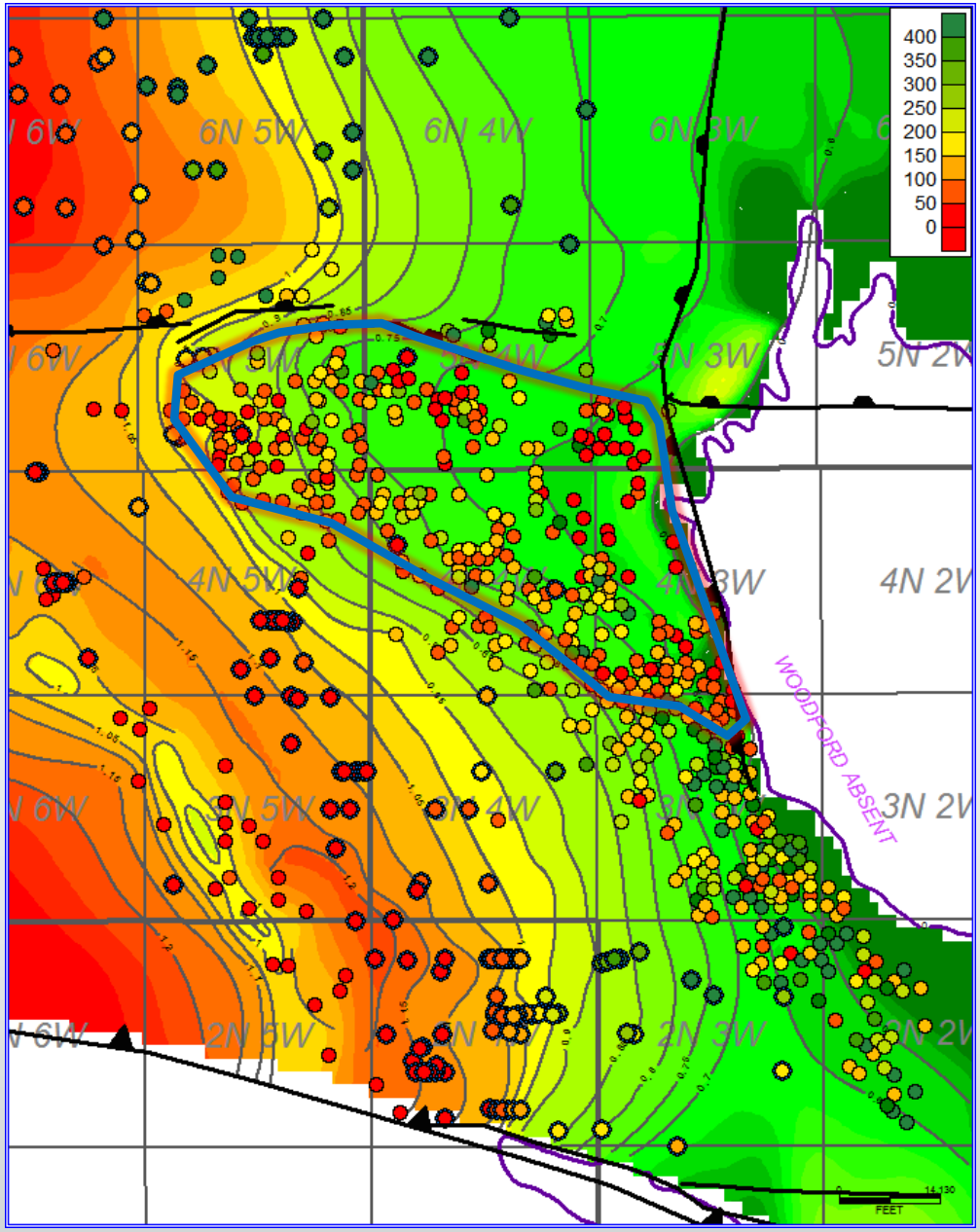
Non Op Wells

CPRP Op Wells

Production Analysis – SCOOP Golden Trend

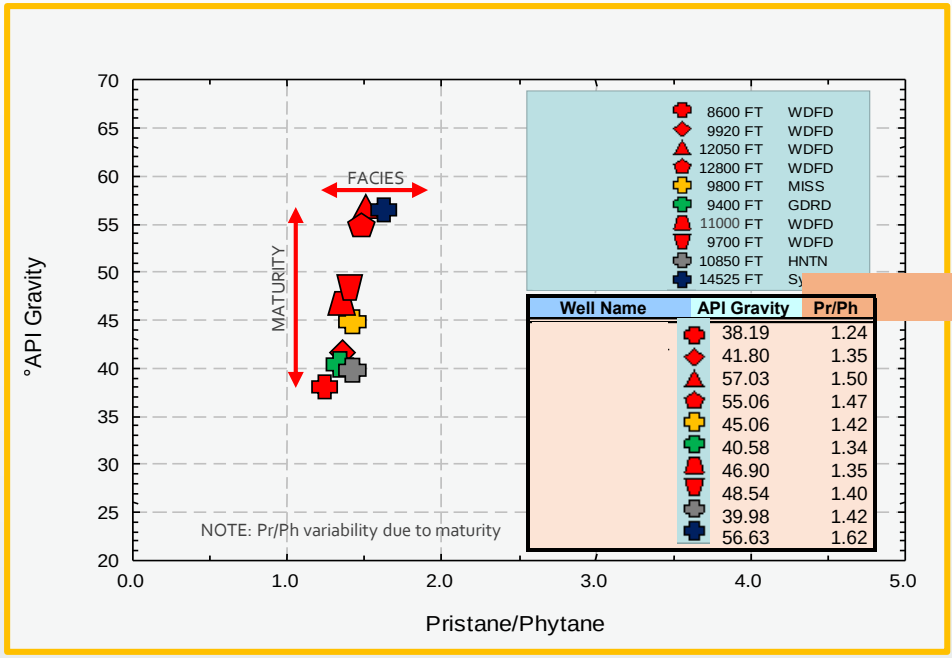
Oil Yield – 60 Day Production

- Produced fluids from vertical wells show a product mix that is different than expected based on Woodford Ro mapping (public and in house data)
- With an increase in horizontal drilling activity, a more detailed expected hydrocarbon map can be created for this area
- Updip area has a similar product mix to that in the Core SCOOP area
- A produced oil and gas sampling and analysis program was started to better understand where hydrocarbons originated in this area
  - Locally derived or migrated from deeper in the trend

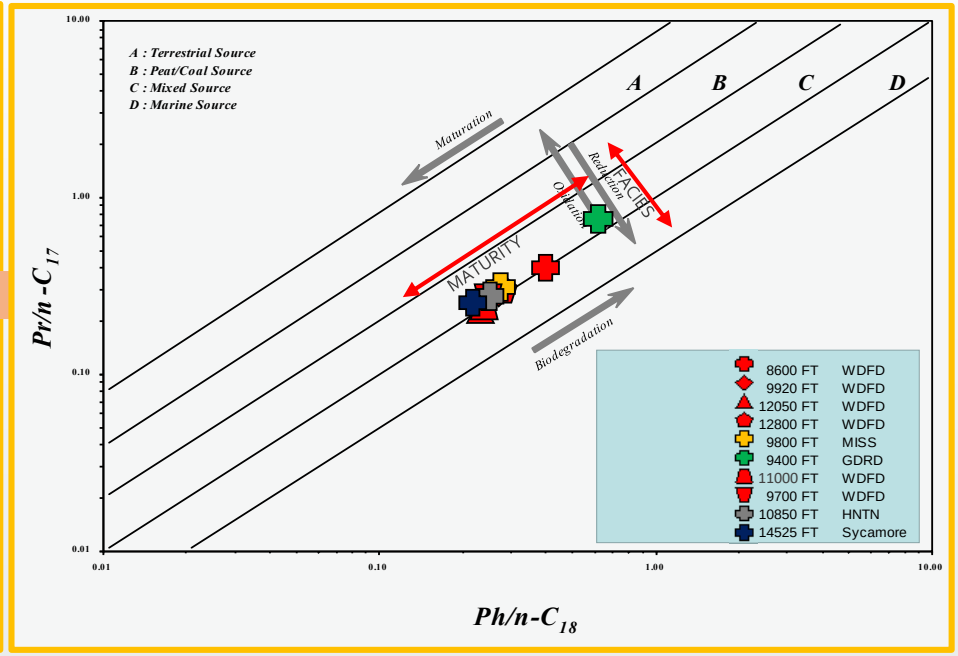


Production Analysis – SCOOP Golden Trend

Whole Oil Analysis



Well Name	API Gravity	Pr/Ph
	38.19	1.24
	41.80	1.35
	57.03	1.50
	55.06	1.47
	45.06	1.42
	40.58	1.34
	46.90	1.35
	48.54	1.40
	39.98	1.42
	56.63	1.62

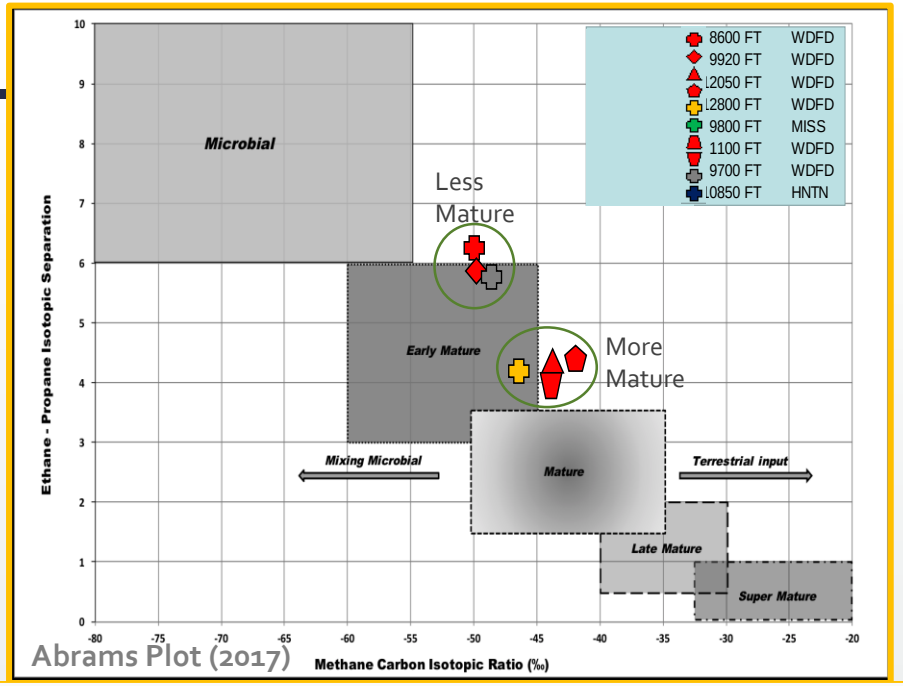


- Oil and gas analysis was completed on 10 samples throughout the area
- Whole oil GC analysis shows similar organic facies, with varying degrees of maturity as one cause of higher than expected gas rates

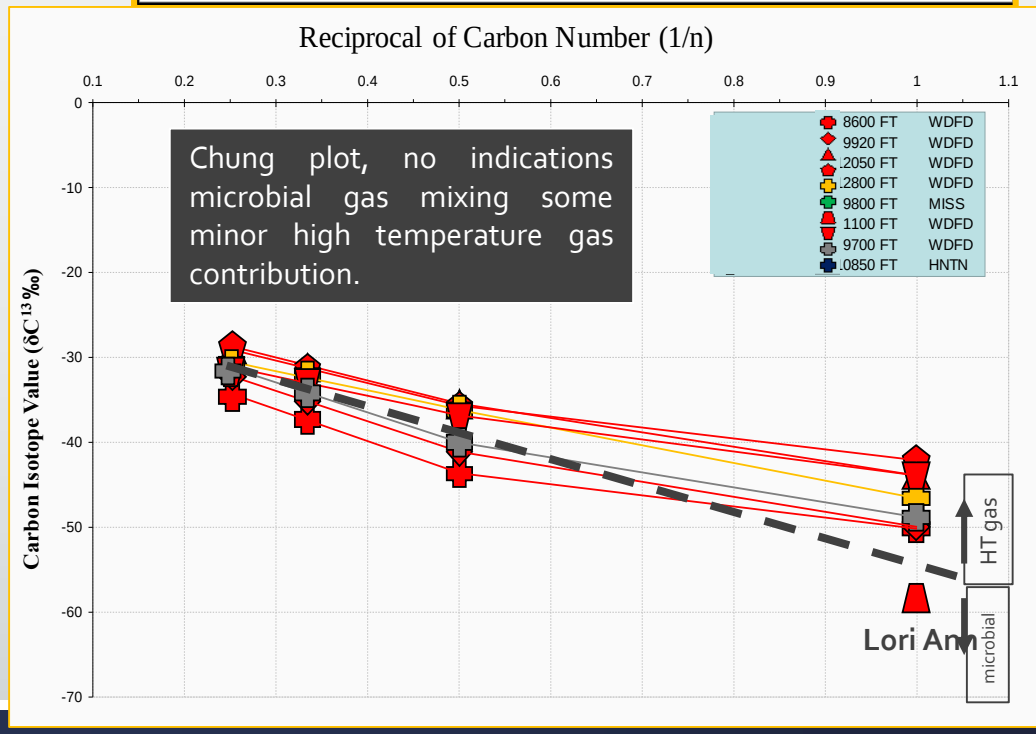
Production Analysis – SCOOP Golden Trend

Gas Isotope Analysis

- Gas isotope analysis completed on 8 wells
- One well (Lori Ann) had a bad sample
- Multiple isotopic comparisons were made which indicate maturity of the gas, and potential for higher temperature gas migration
- Abrams plot shows that gases seem to be generated at relatively lower maturities
- Chung plot shows a slight increase in the trend of the Carbon Isotope Value, indicating HT gas



Abrams Plot (2017)



Summary/Future work

- Updip portion of SCOOP Woodford shows product mix similar to that in the deeper SCOOP trend
- Reservoir mapping and core analysis of the Mississippian section in updip portion of the SCOOP show variable facies (siltstones and shales) from southwest to northeast
- Wells drilled in different facies of Mississippian section show promising production results, which when paired with geomechanical data lead to multiple potential landing/drilling targets
- Regional production and fluid analysis testing will be continued to further study predicted vs actual product mix
- Continued core and log analyses are planned throughout the area to further enhance our understanding of the Goddard and Mississippian reservoirs
  - Depositional environments for each reservoir will be key to understanding facies changes throughout the area