Structural Control of the Point Pleasant Formation Deposition and Production*

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Abstract

Early drilling and production observations in the Point Pleasant Formation in Ohio suggest that structural setting influences production. To test structural setting versus production, Point Pleasant horizontal completions (~800 wells) were categorized into five structural settings based on Trenton and shallow residual mapping. The settings are (1) Structural High, (2) Transitional High, (3) Platform, (4) Basinal, and (5) Deep Basin. Cumulative production in terms of thousand cubic feet gas equivalent (Mcfe) were calculated and normalized to Mcfe/1,000 feet of lateral. The structural setting with the highest cumulative production after 24 months is the Basinal setting which produced 12% more reserves than the average, and 30% more than the Structural High, the worst performing structural setting. The Structural High, Transitional High, and Deep Basin settings all fell below the average 24-month production. The advantage of the Basinal setting is that it is structurally low, low relief, and normally near a carbonate source. These geologic elements limit the energy and oxygen within the basin while providing the proper carbonate-shale ratio. The Basinal setting offers the best environment for the deposition and preservation of organic material. Existence of the organic beds can be observed in cores, geophysical logs, and formation imaging logs. The Platform setting is a structurally elevated area inside the Basinal setting and has the advantages of the Basinal setting. Comparison of Point Pleasant core total organic carbon values between Structural High, Transitional High, and Basinal wells within similar thermal maturity bands show that more organic material is preserved in the Basinal setting than in the Structural High and Transitional High settings. The Deep Basin setting has total organic carbon values similar to the Basinal setting, but has lower carbonate-shale ratios and higher clay content that constrain production. The quantity, thickness, continuity, and subsequent preservation of the organic beds appear to be critical components in the enhancement of Point Pleasant production. The preservation of organic material in the Point Pleasant shale is controlled by underlying basement structures and Knox paleotopography. The organic beds may also be the starting point for an interconnected horizontal porosity system that develops as thermal maturity progresses.

References Cited

Bohacs, K.M., 1998, Contrasting Expressions of Depositional Sequences in Mudrocks from Marine to Nonmarine Environs, *in* J. Schieber, W. Zimmerle, and P. Sethi (eds.), Shales and Mudstones, Volume I: E. Schweizerbart'sche Verlagsbuchhandlung, Nägele u. Obermüller, p. 33-78.

Buckner, N., R.M. Slatt, B. Coffey, and R.J. Davis, 2009, Stratigraphy of the Woodford Shale from Behind-Outcrop, Drilling, Logging, and Coring: AAPG Annual Convention, San Antonio, TX, April 20-23, 2008, Search and Discovery Article #50147 (2009). Website accessed October 2017.

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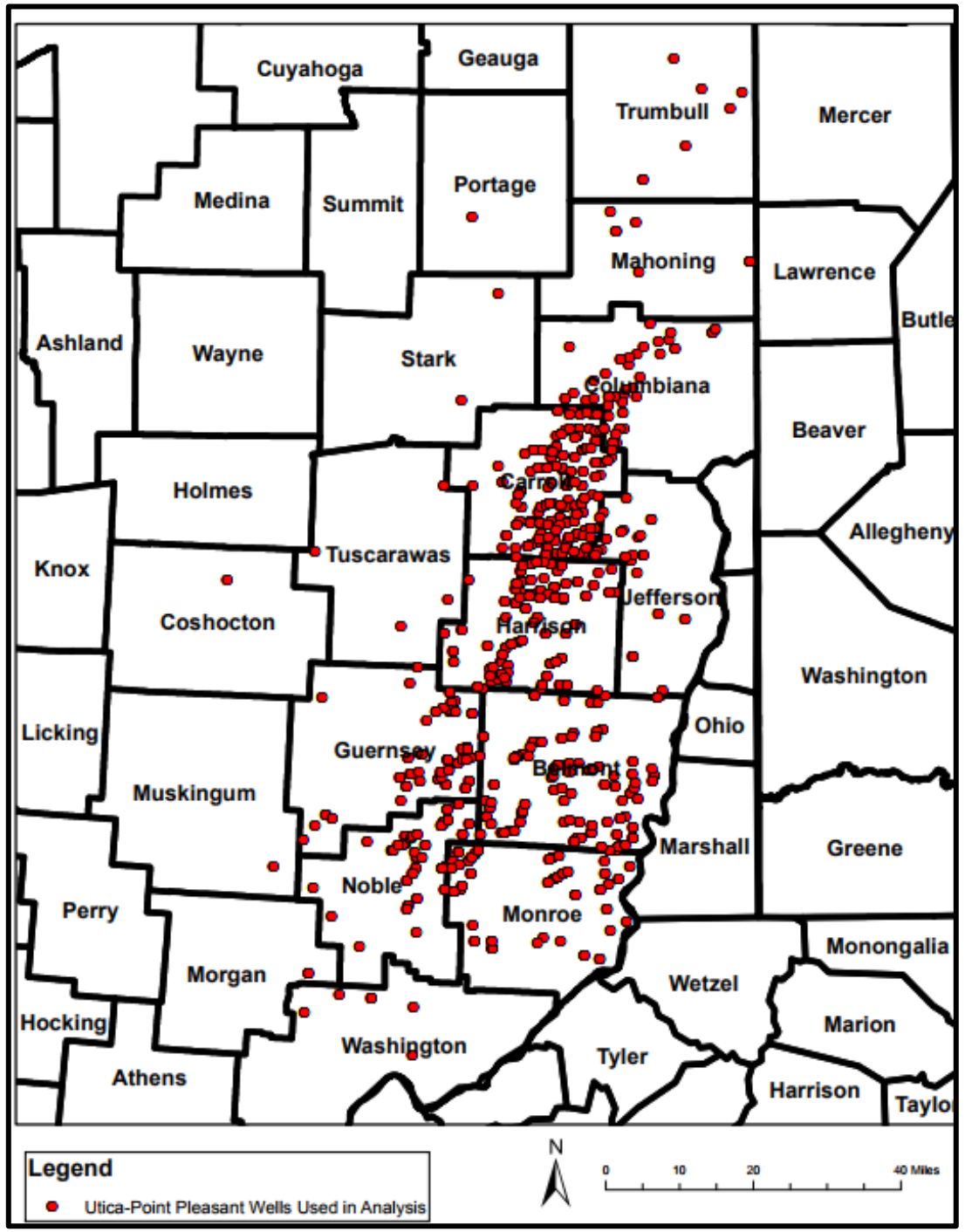
Agenda:

- Procedure: Residual Mapping & Assigning Structural Setting
- Well Performance vs. Structural Setting
- Organic Beds Theory
- What Makes a Good Utica/Point Pleasant Well
- Summary & Geological Optimization



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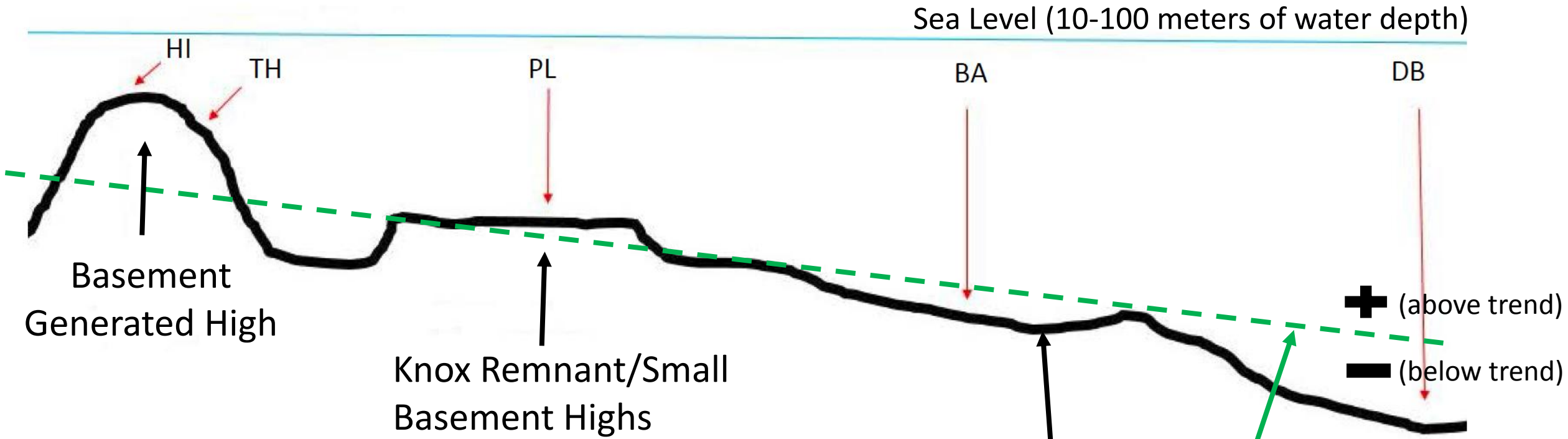
Analysis of Horizontal Utica/Point Pleasant Well Performance in Ohio

- ODNR production data through 1Q 2017
- 1,535 wells with production and known lateral length
- 1,492 wells with adequate production to determine EUR
- Two-phase EURs with 6:1 gas to oil equivalency

Structural Setting	Well Count
BA	459
PL	310
DB	530
HI	60
TH	133
All Settings	**1492**

Residual Mapping & Structural Settings



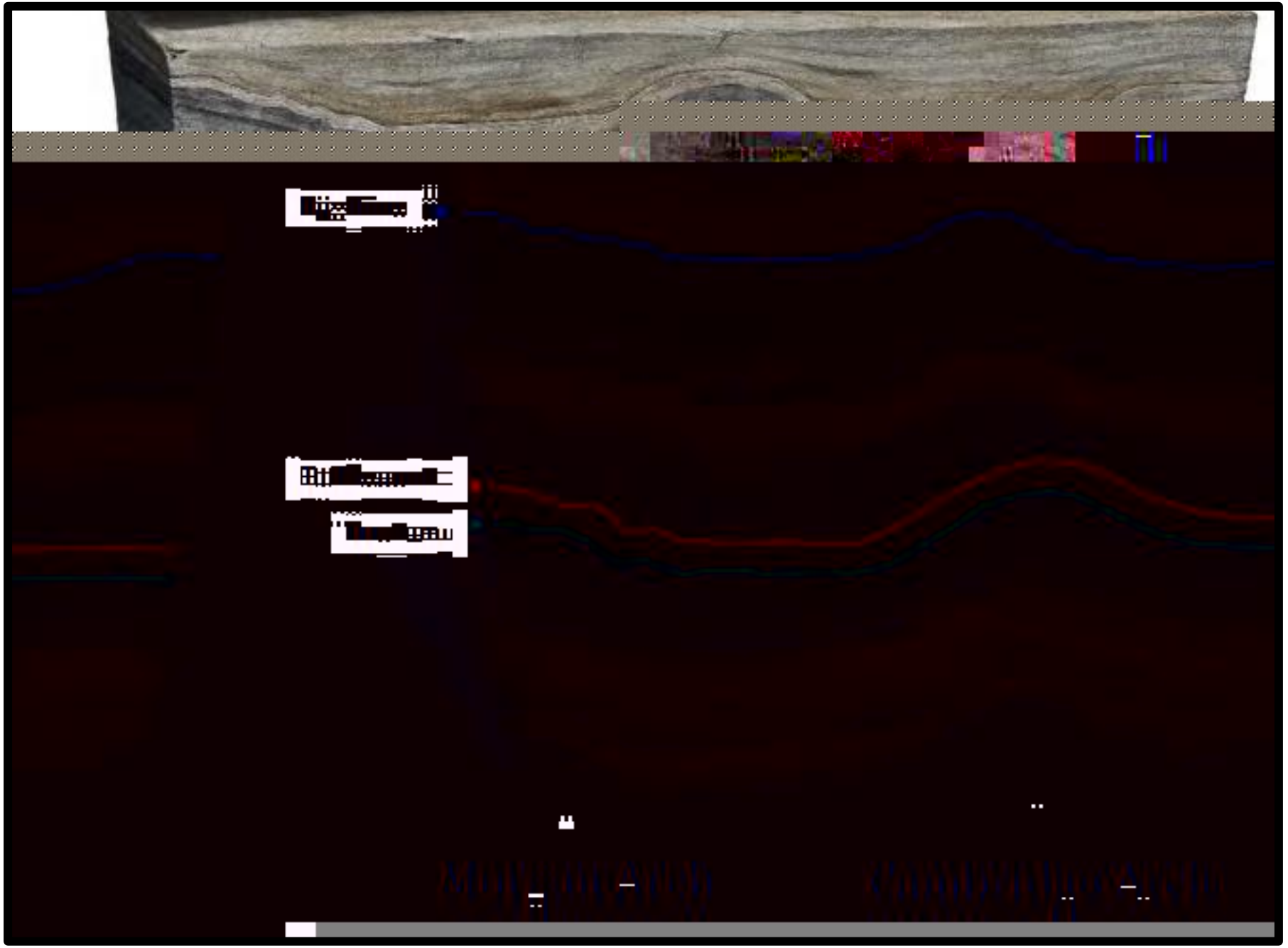
HI - STRUCTURAL HIGH
TH - TRANSITIONAL HIGH (SLOPE)
PL - PLATFORM
BA - BASINAL
DB - DEEP BASIN

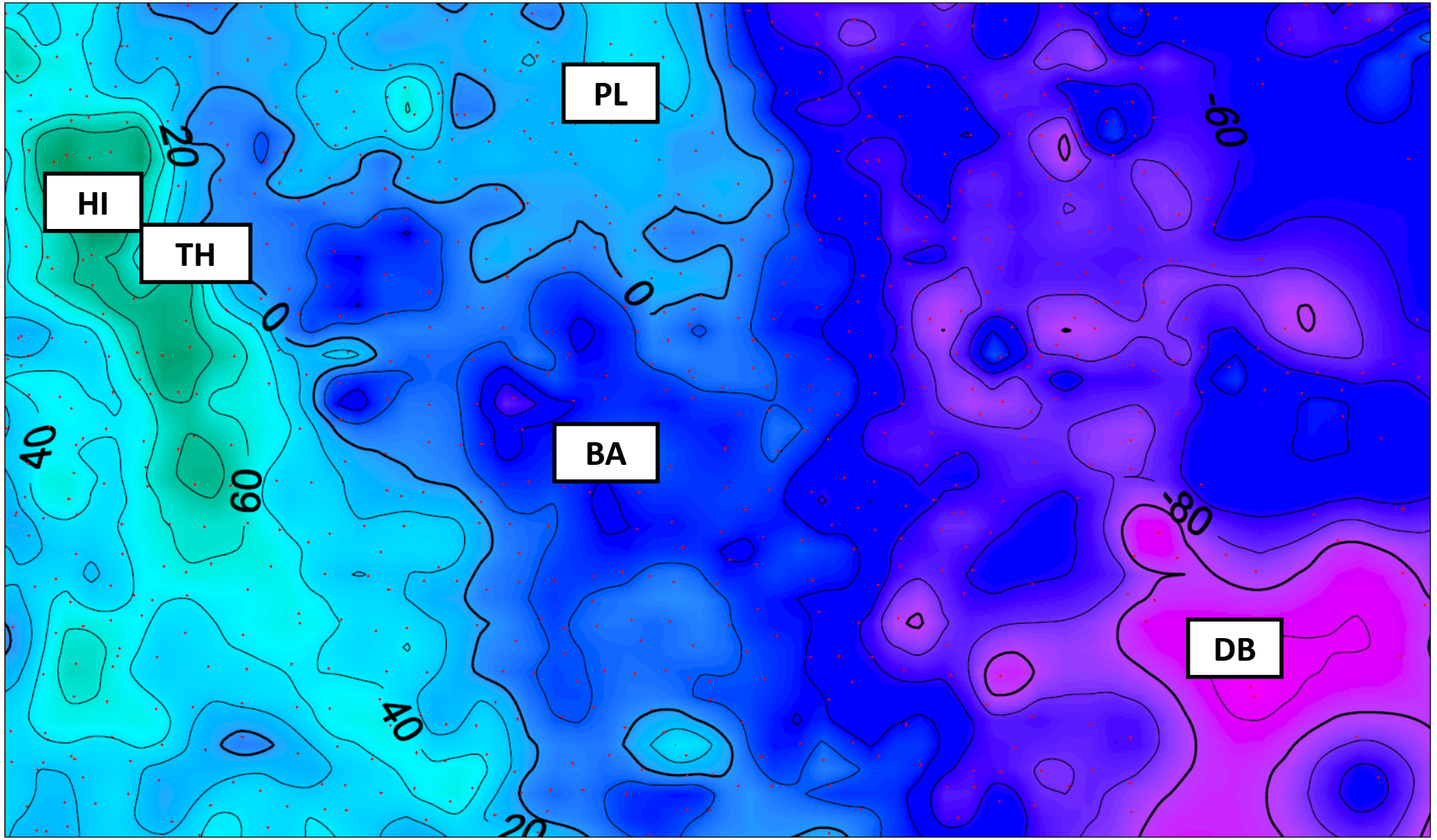
<u>Residual Mapping</u>

A.) Trenton Structure Map
B.) 2nd Order Trend Surface
C.) A-B= Trenton 2nd Order Residual

More shale compaction in the lows

<u>Differential Compaction</u>





- 53,000 Onondaga tops in EMF's eastern OH database
- Structure confirmed using 3D Seismic in many areas
- 4,000 acres in example at left

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SHALLOW INDICATOR
STRUCTURAL 2ND ORDER RESIDUAL
EXAMPLE

PREPARED BY EMF		**Date:** 21 February, 2017
	Scale:	

Depositional Model of Geological Settings

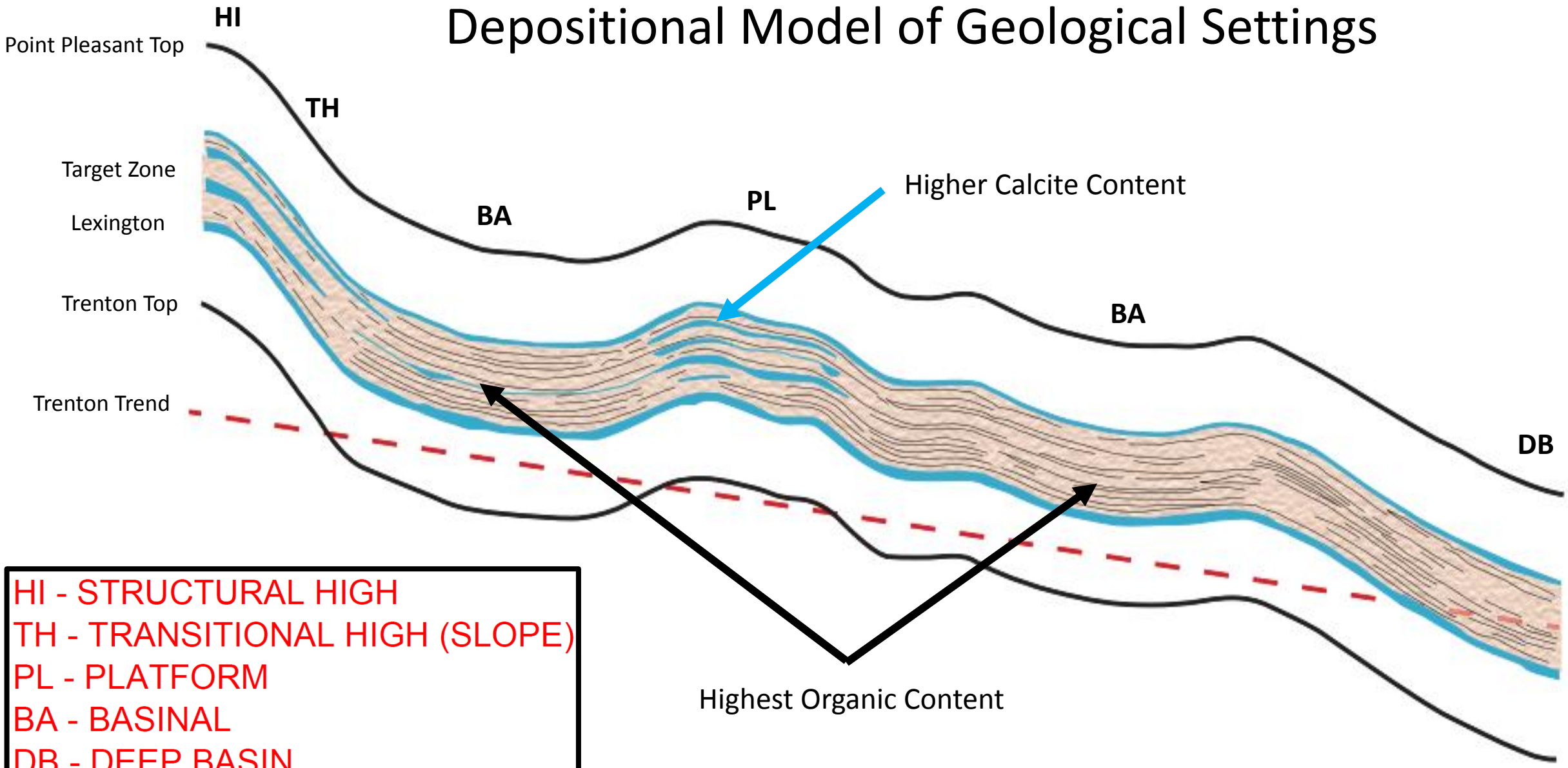

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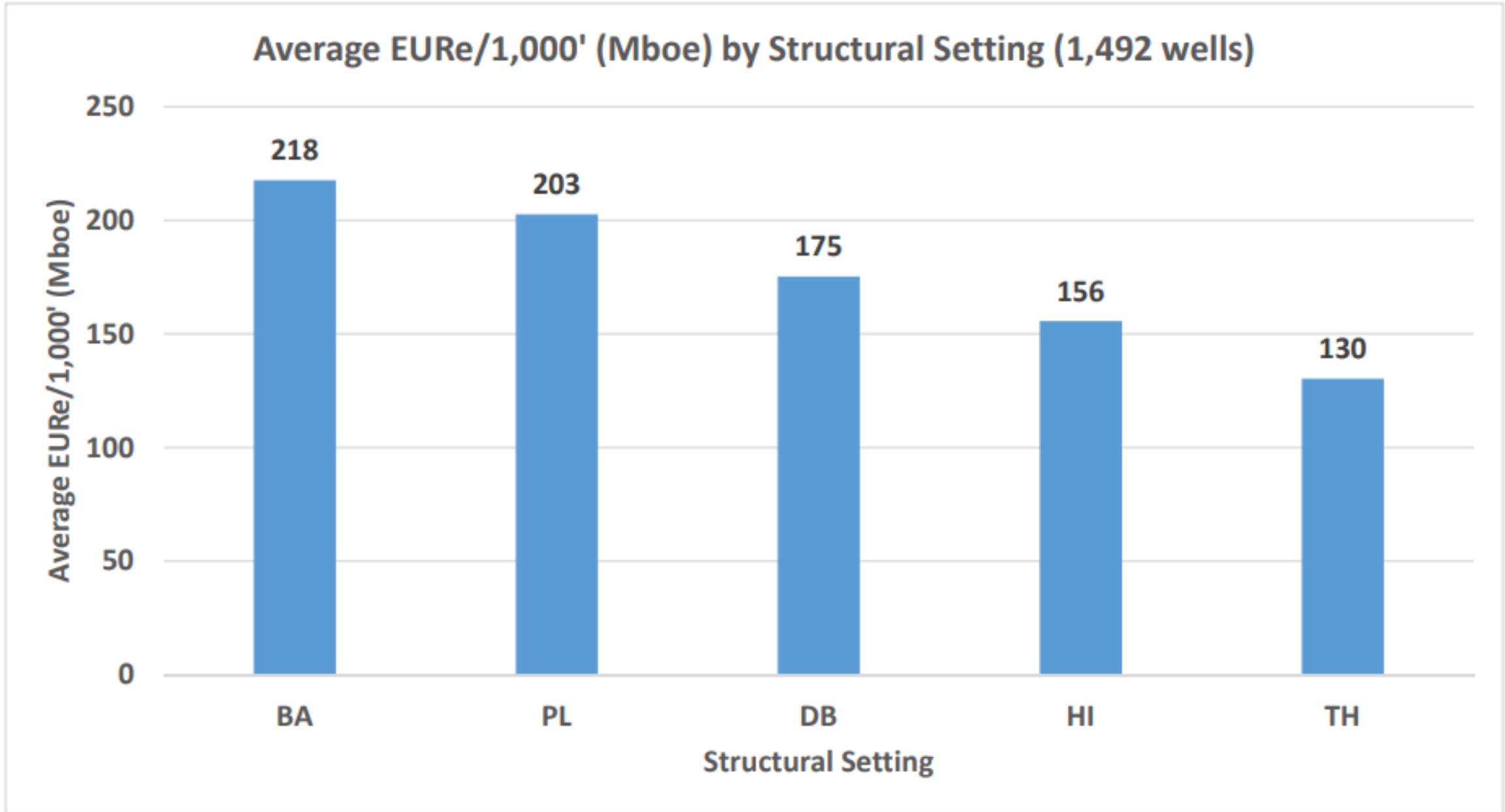
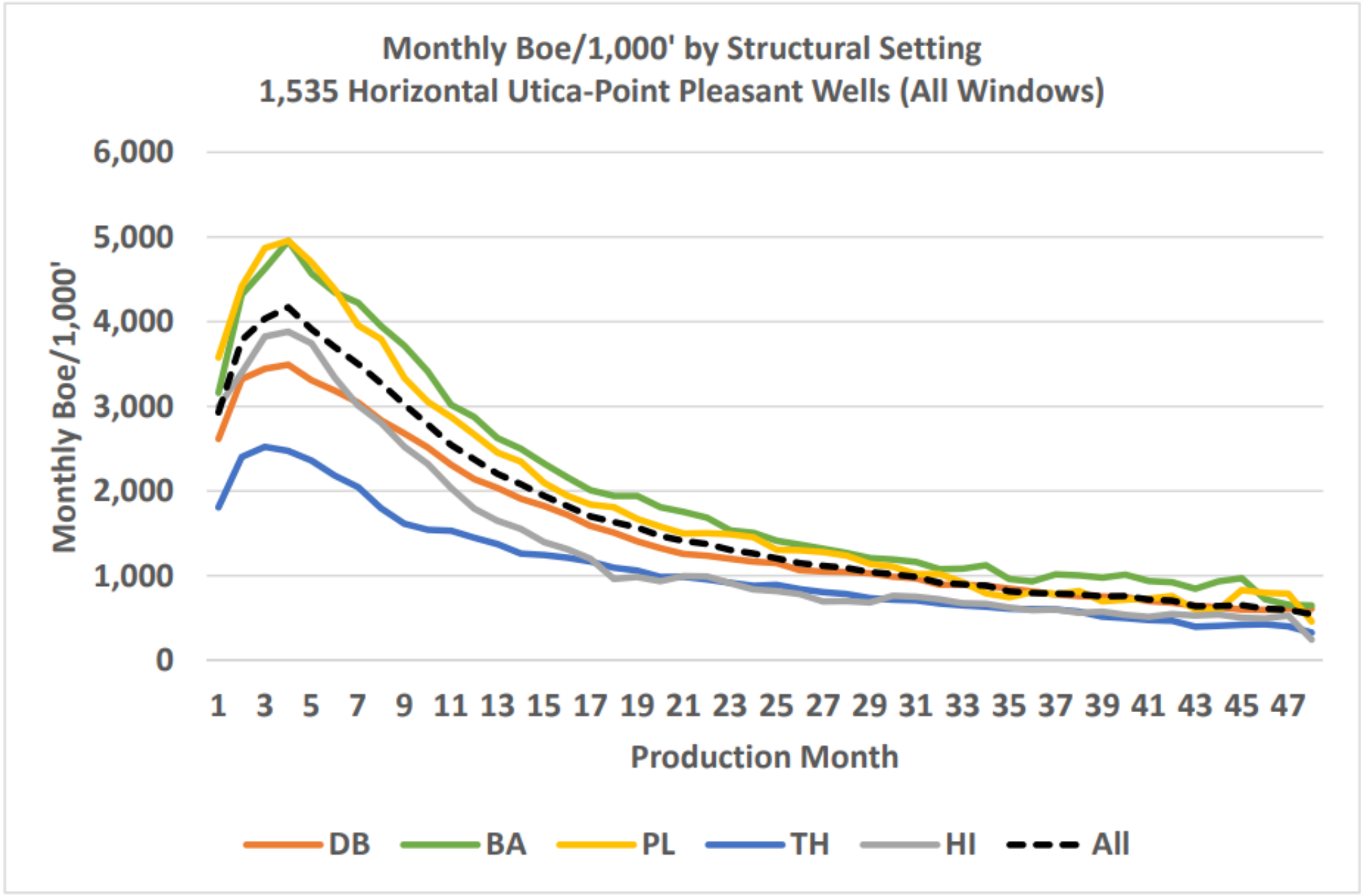
Figure Generated By: Gregory Nadon
Ohio University

Well Performance vs. Structural Setting



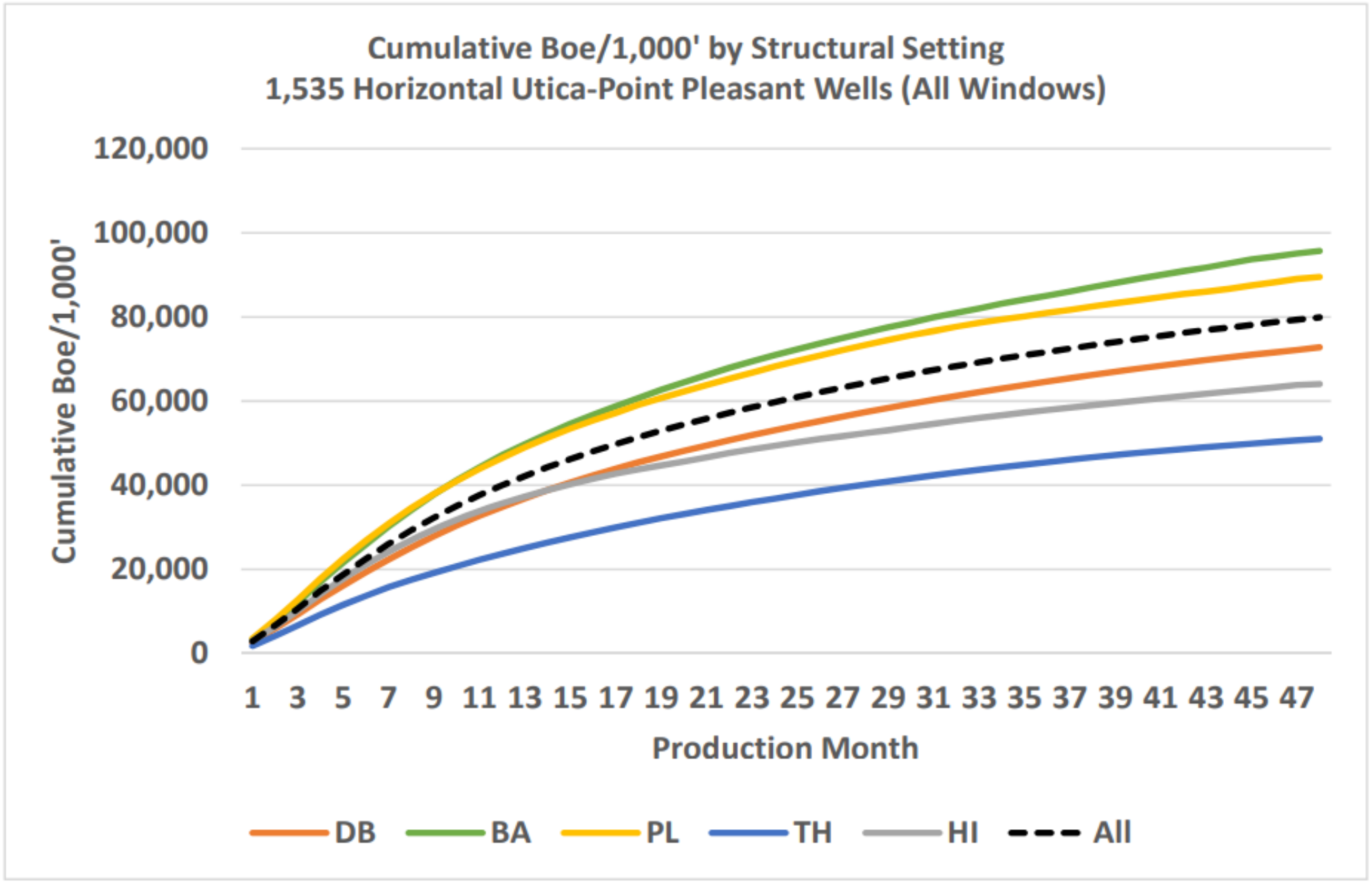
Includes all thermal maturity windows and completion methods

Rate vs Time



Includes all thermal maturity windows and completion methods

Cumulative vs Time



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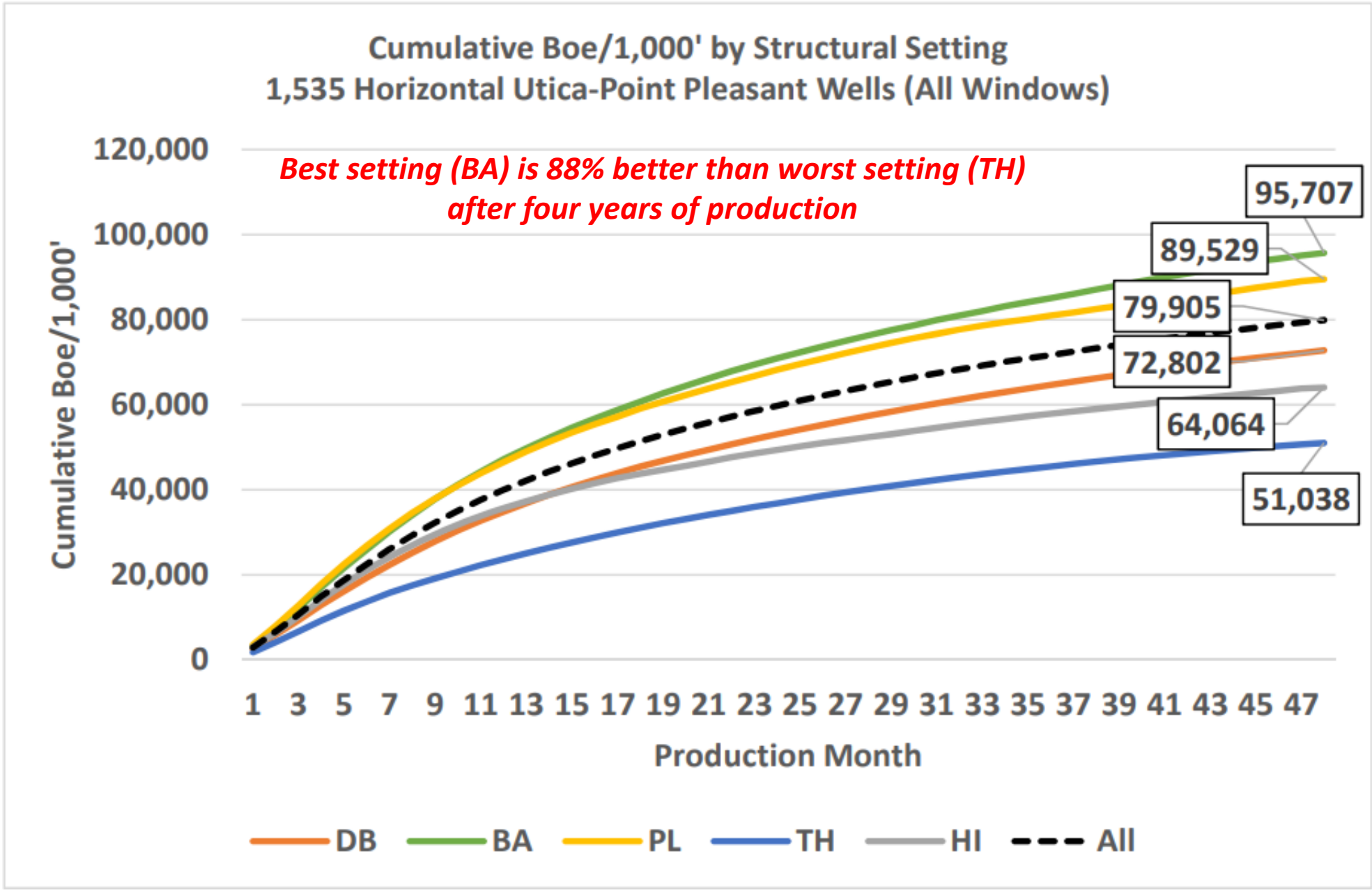
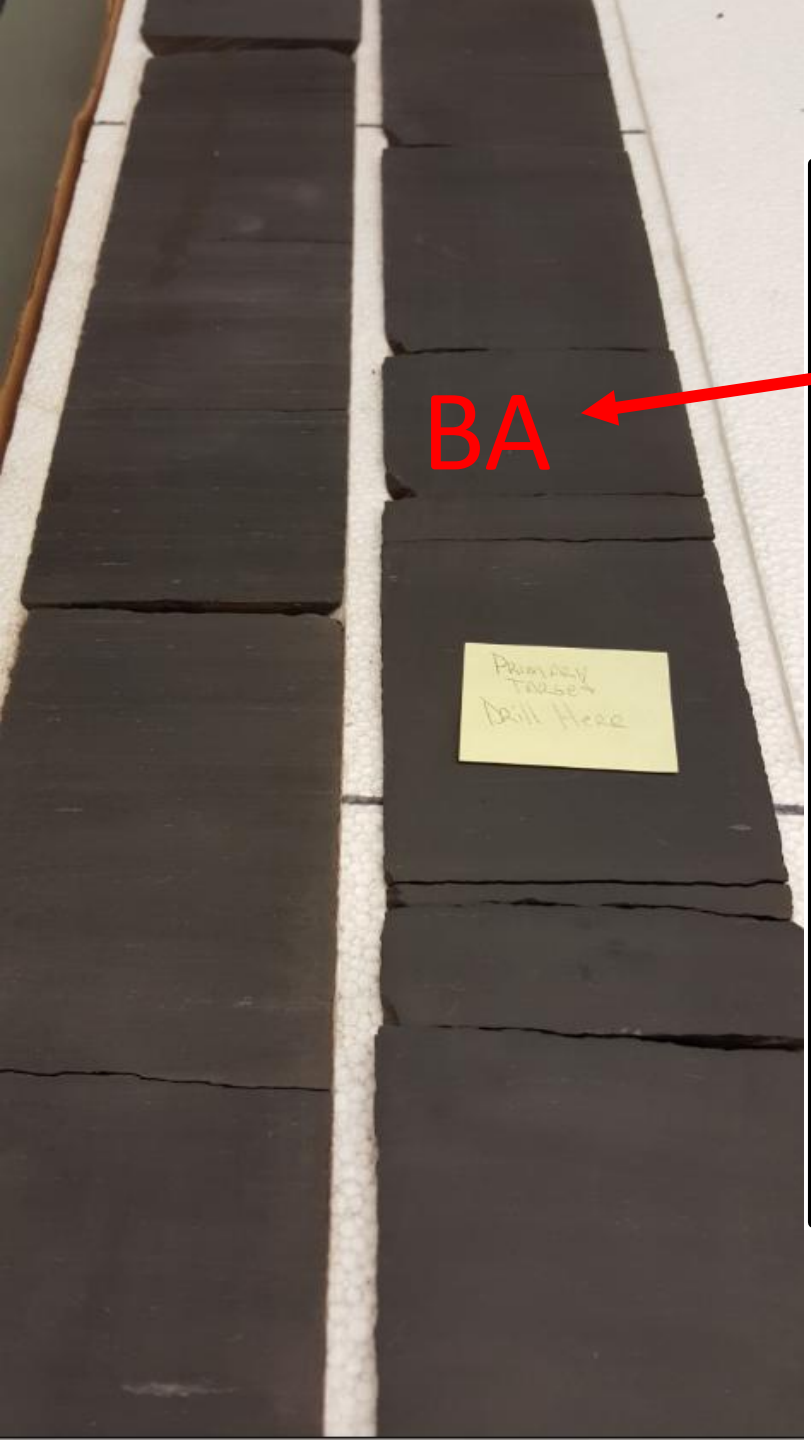
Cumulative vs Time

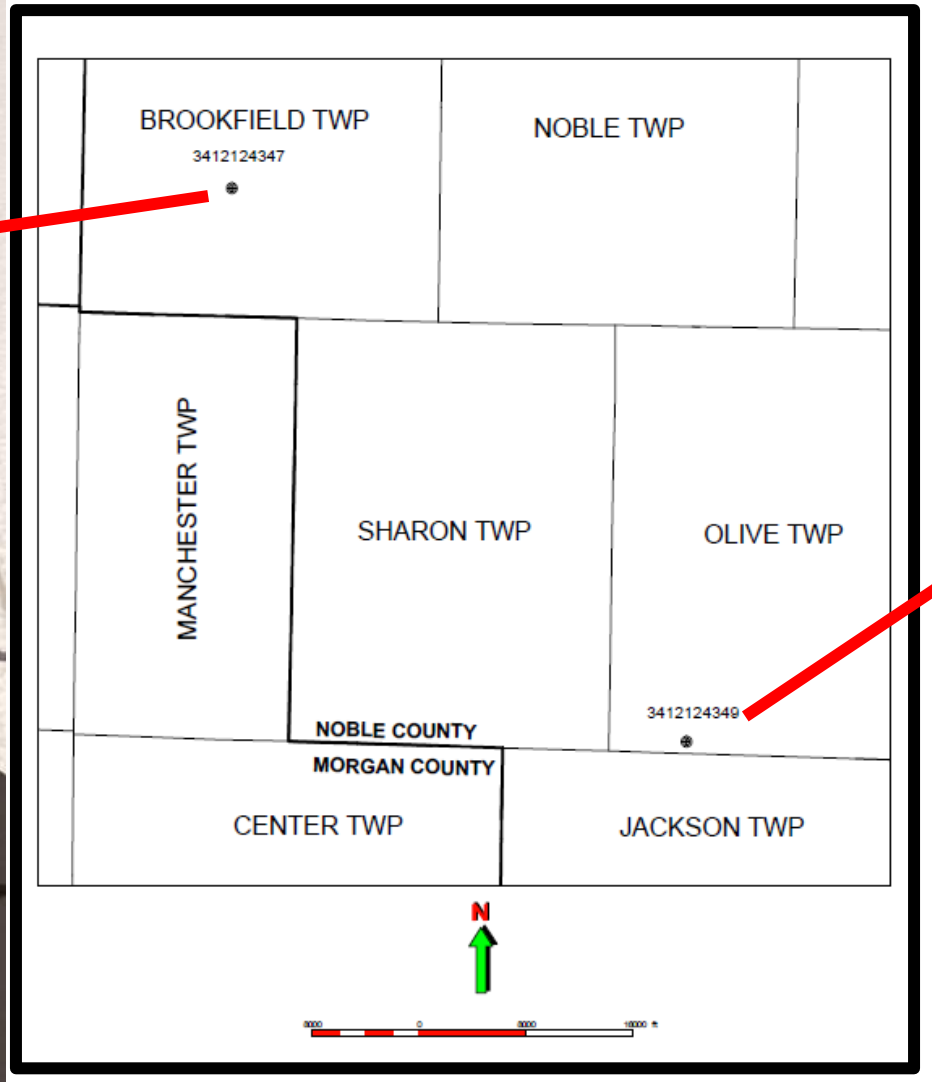


Includes all thermal maturity windows and completion methods

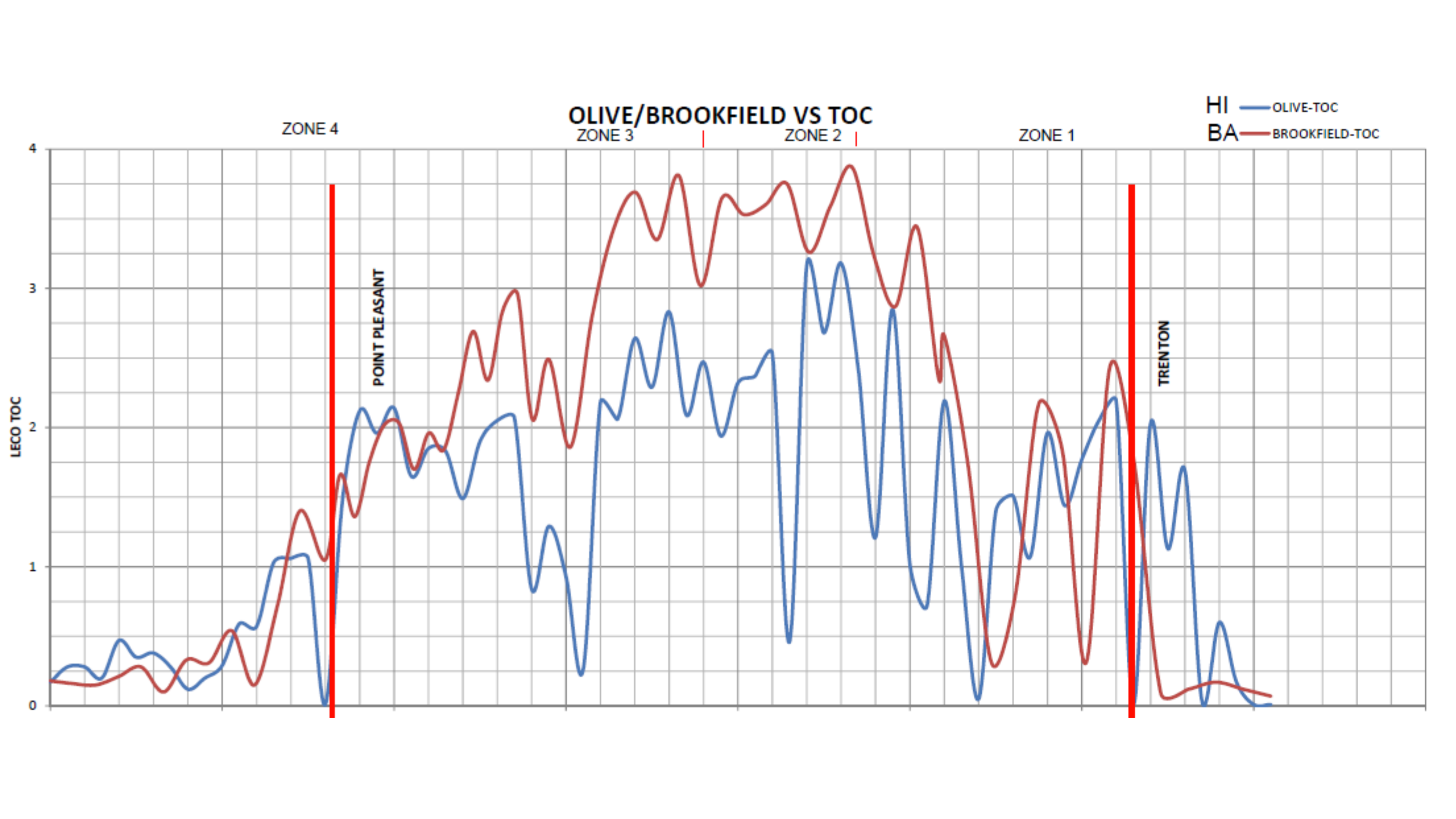
Point Pleasant Zone 2 Comparison



BA



HI


OLIVE/BROOKFIELD VS TOC
HI
OLIVE-TOC
BA
BROOKFIELD-TOC
ZONE 4
ZONE 3
ZONE 2
ZONE 1
POINT PLEASANT
TRENTON
LECO TOC
4
3
2
1
0

Organic Beds Theory

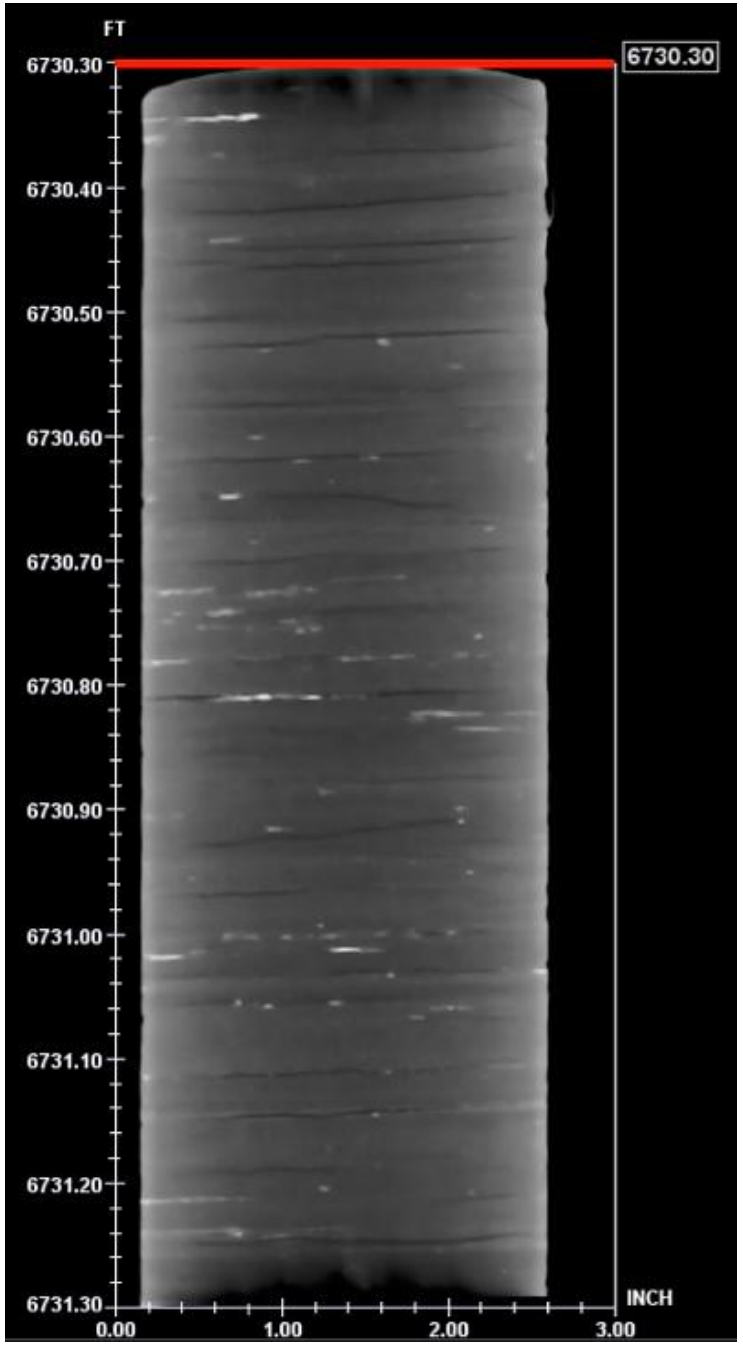
Greater occurrence of Point Pleasant bedding planes with increasing Total Organic Carbon (TOC)

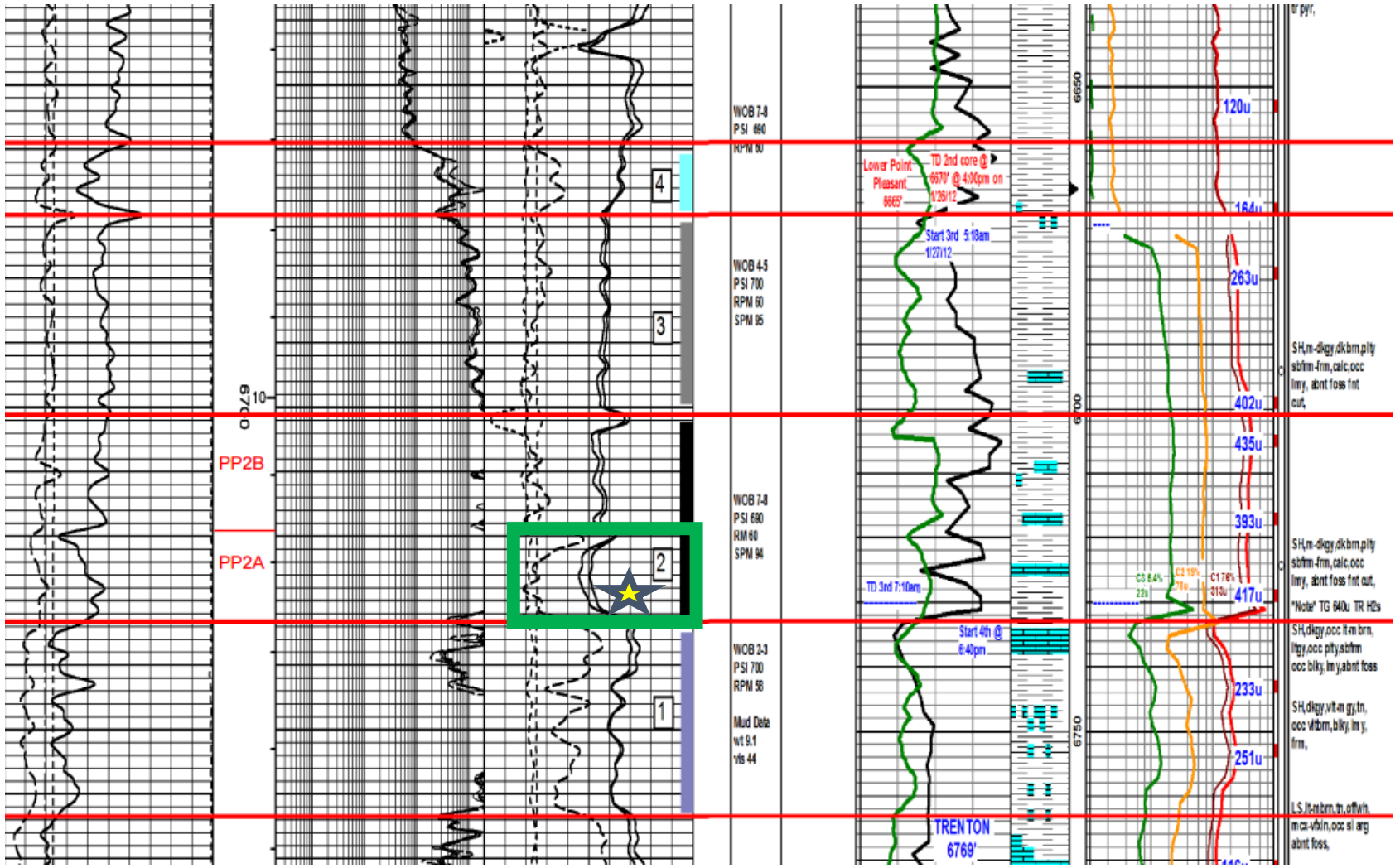
Kerogen= 1.1 g/cc
Oil Density= 0.8 g/cc
Gas Density=0.0008 g/cc

Lower bulk density correlates with higher TOC values

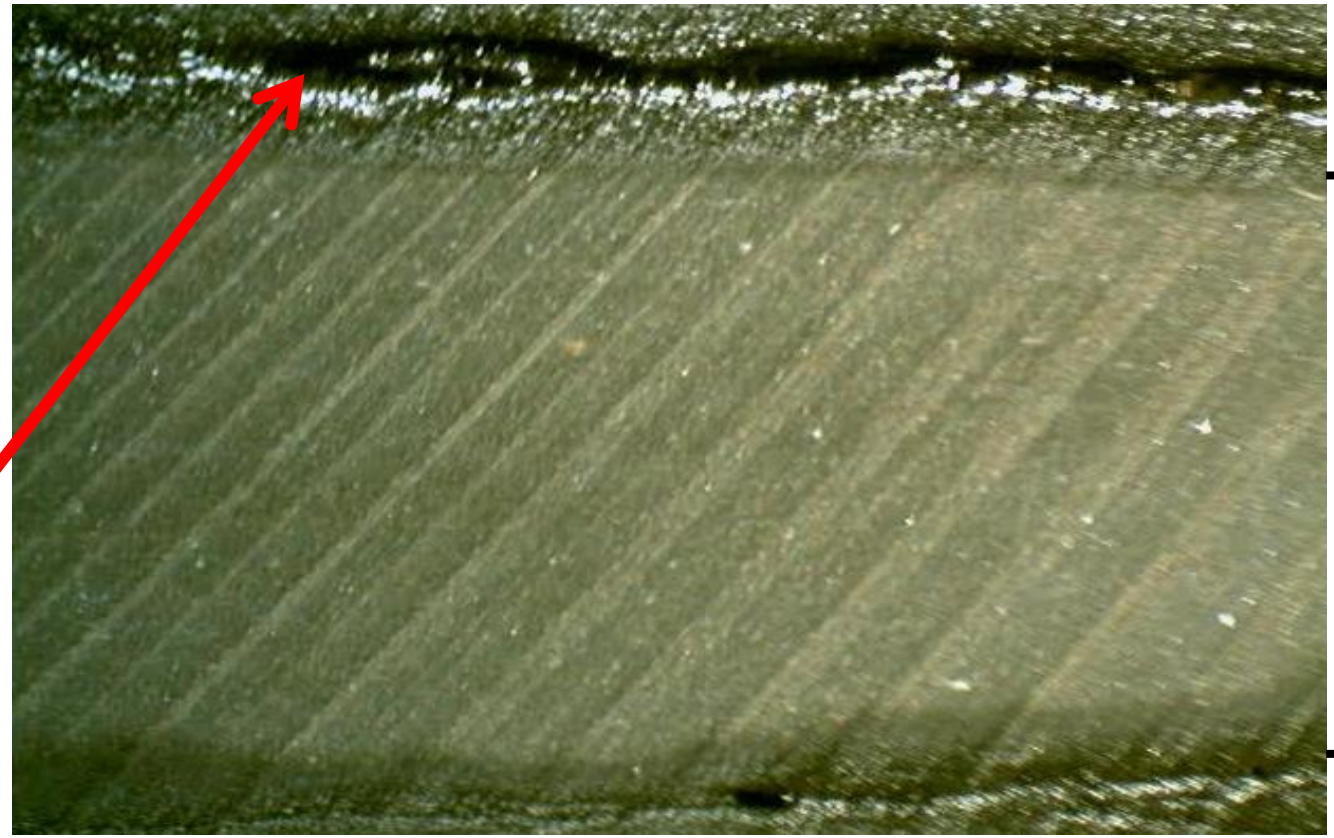
Least dense rock highest TOC

High Resolution CT Scanner and Geophysical Log Brookfield Township, Noble County-Oil Window





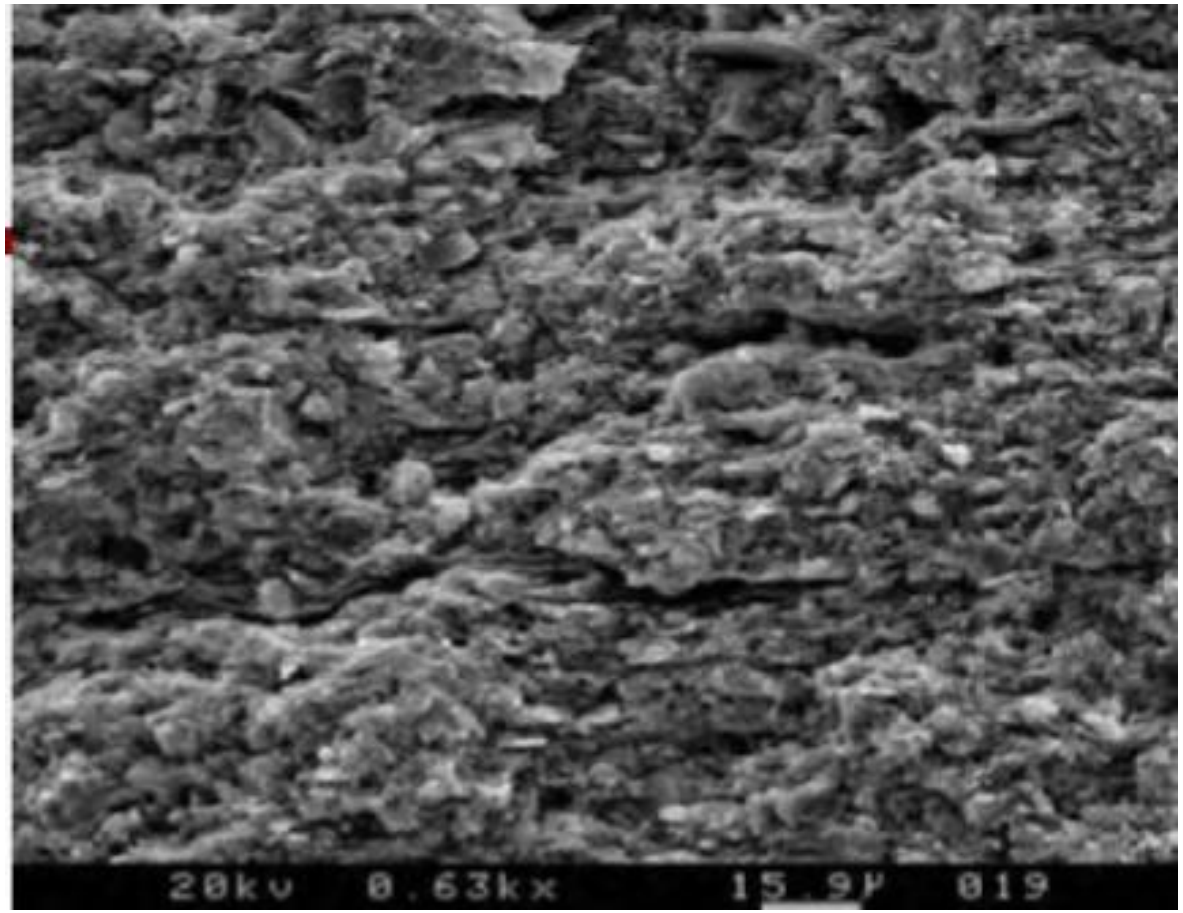
Close up of Point Pleasant bedding plane in Brookfield Township, Noble County, Ohio-Oil Window

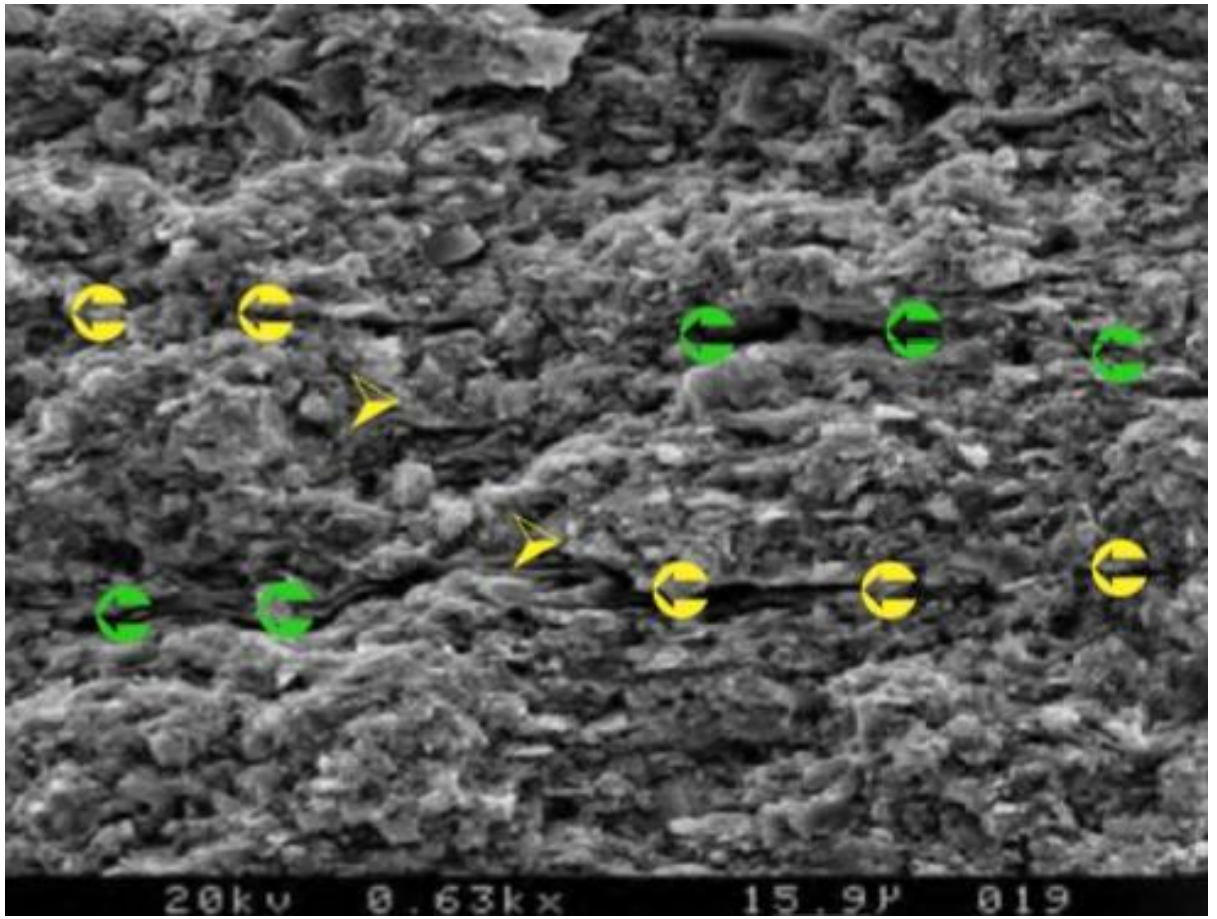


Organic Bed

Clay Rich

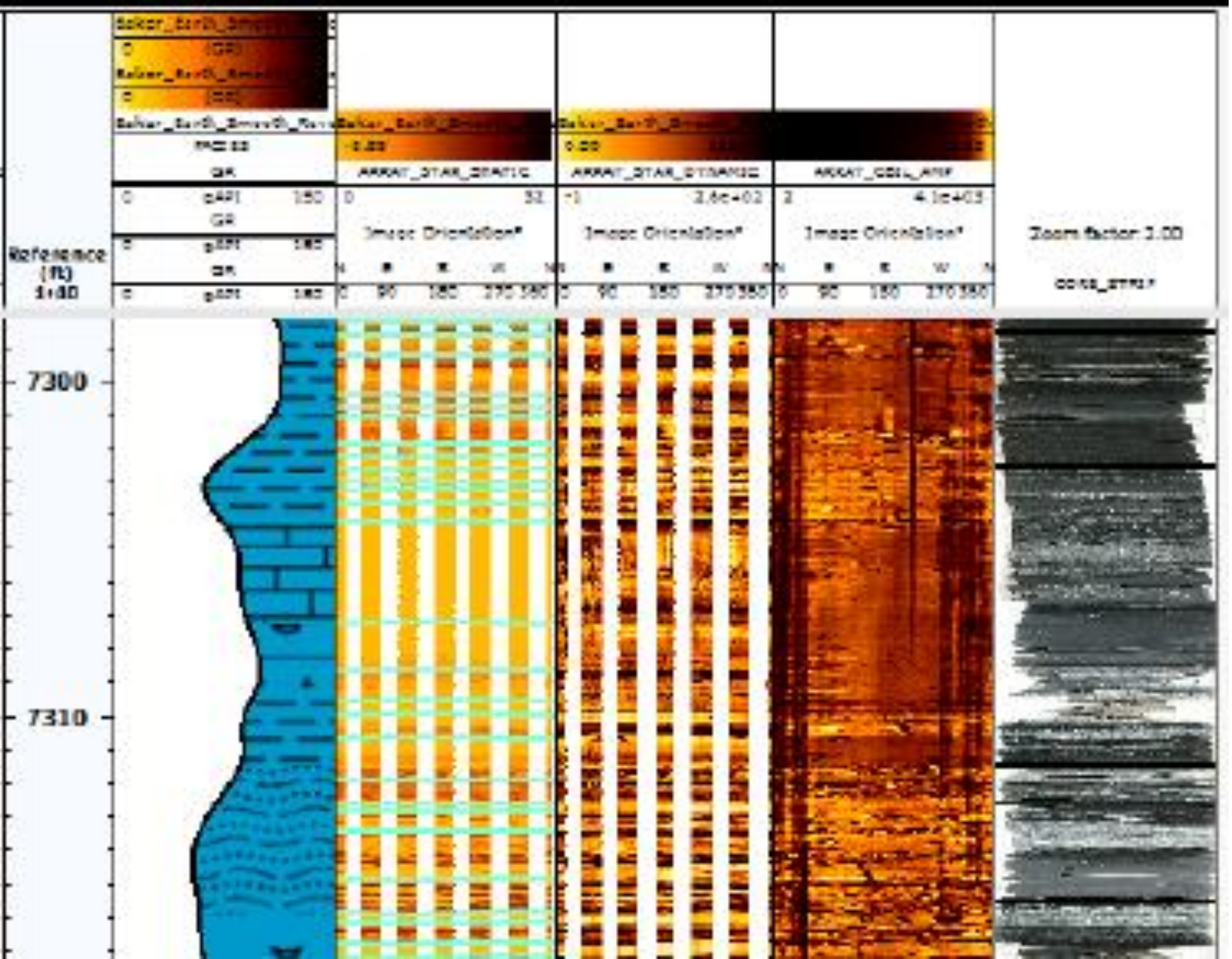
Bed is 0.4 mm





“Horizontally Laminated Organic Beds,” also know as planes of weakness by other authors.

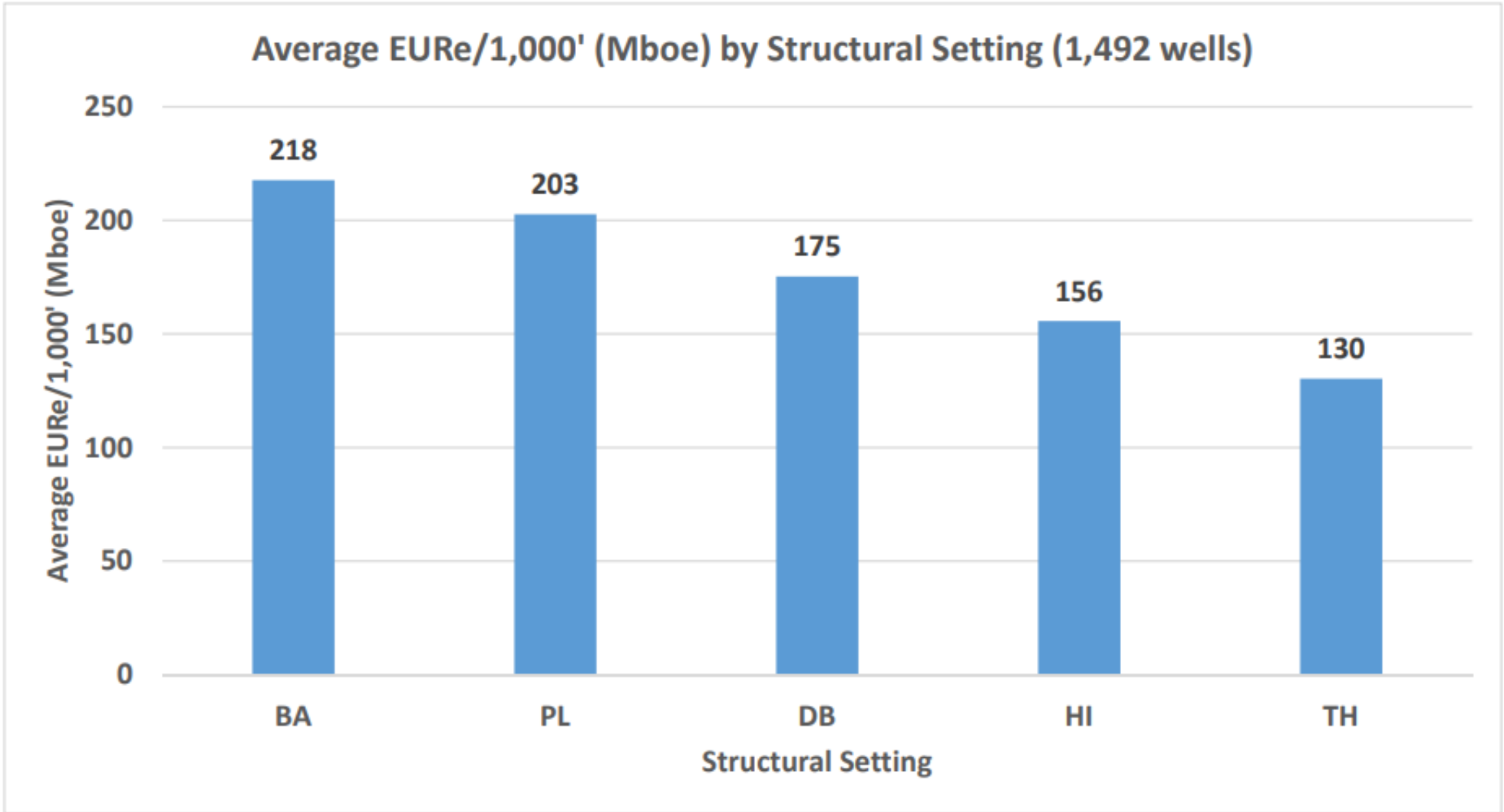
Stratigraphy of the Woodford Shale from Behind-Outcrop, Drilling, Logging, and Coring (Buckner and Slatt, 2009).



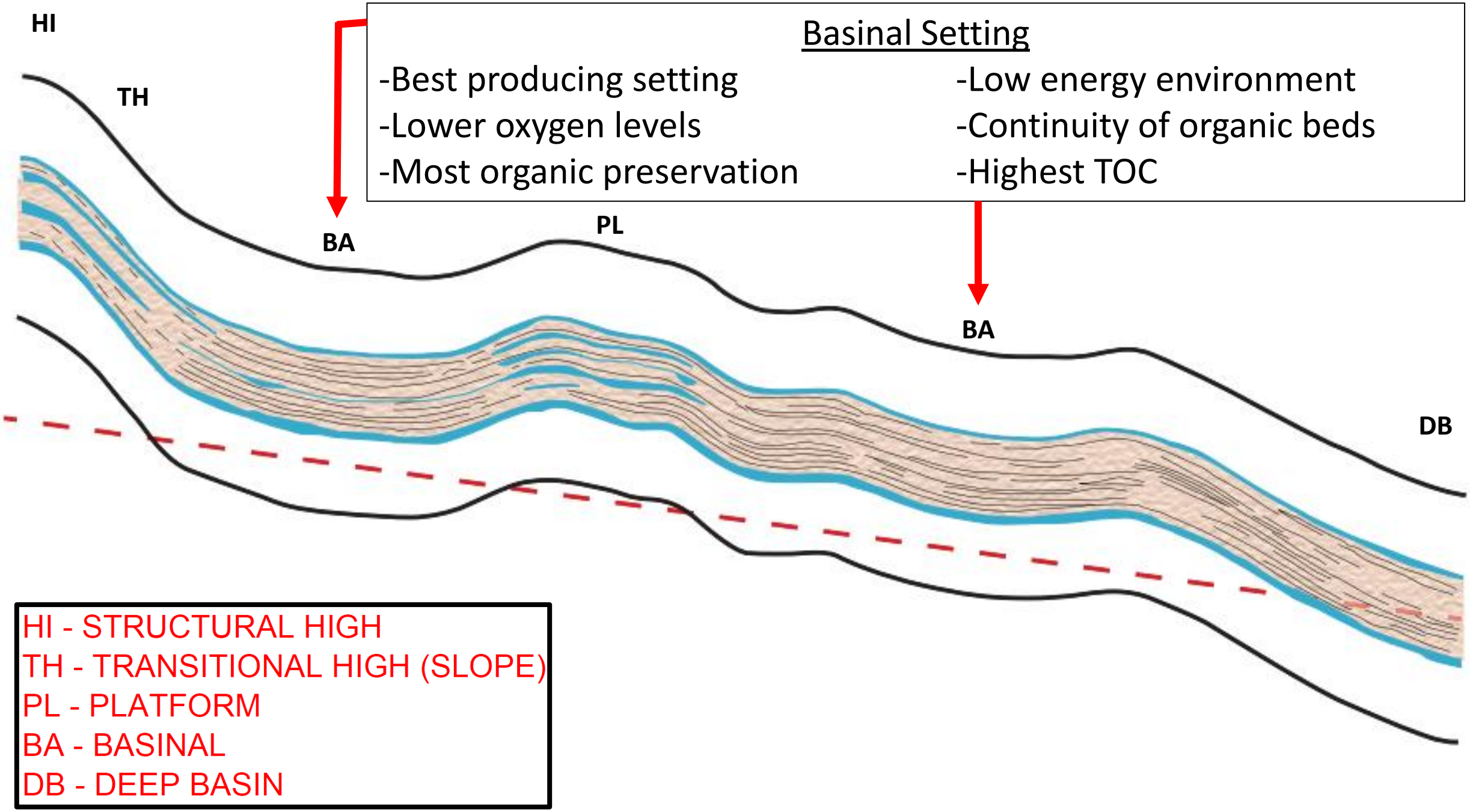
FMI Log Olive Township, Noble County Condensate Window

Very thin resistive bedding layers observed on the STAR resistivity image correspond to alternating layers of mudstone, organic material, and bioclastic fragments.

Explanations of Well Performance by Structural Setting



Includes all thermal maturity windows and completion methods



Basinal Setting

- -Best producing setting
- -Lower oxygen levels
- -Most organic preservation
- -Low energy environment
- -Continuity of organic beds
- -Highest TOC

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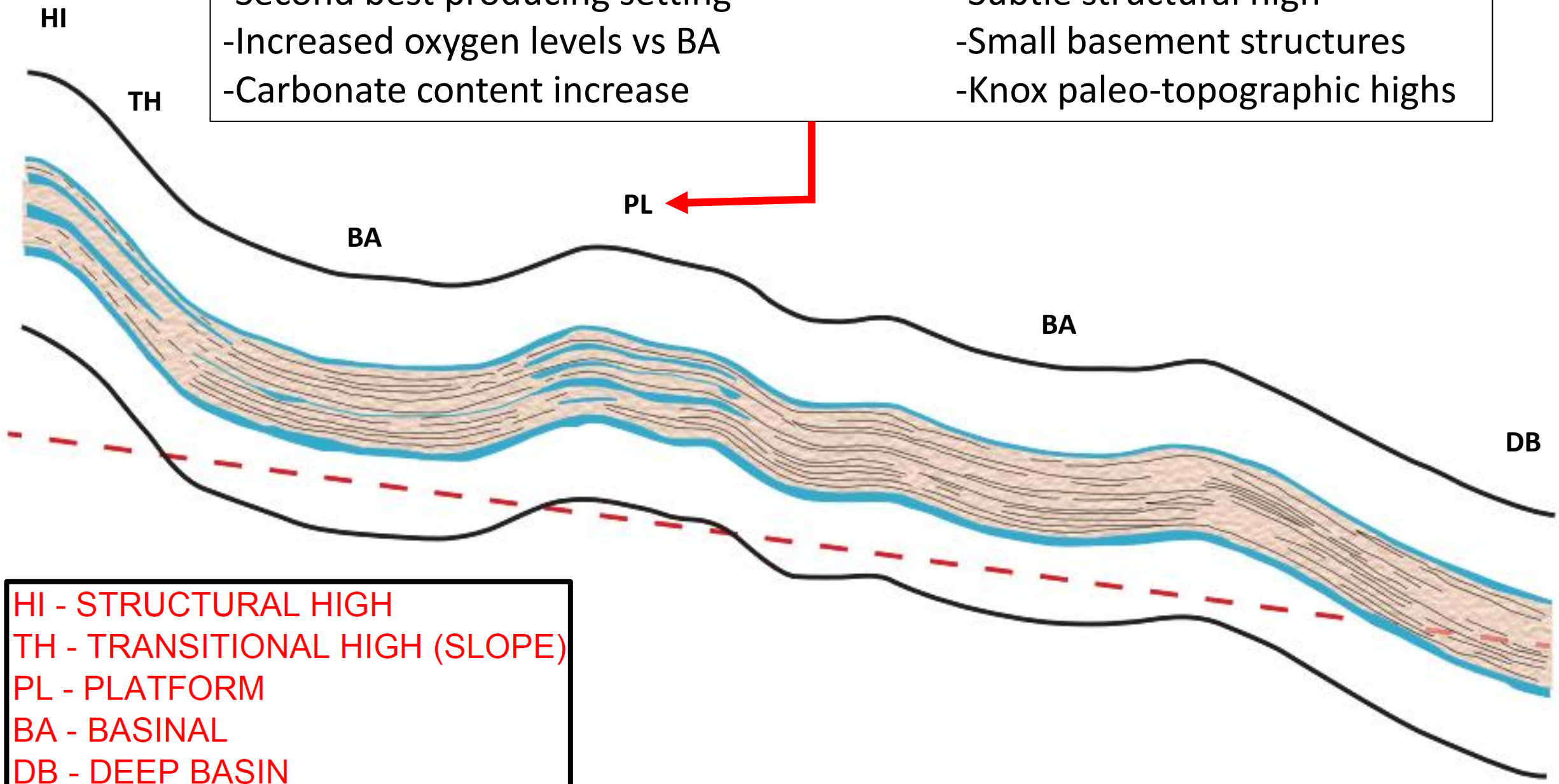
Platform Setting

-Second best producing setting
-Increased oxygen levels vs BA
-Carbonate content increase
-Subtle structural high
-Small basement structures
-Knox paleo-topographic highs



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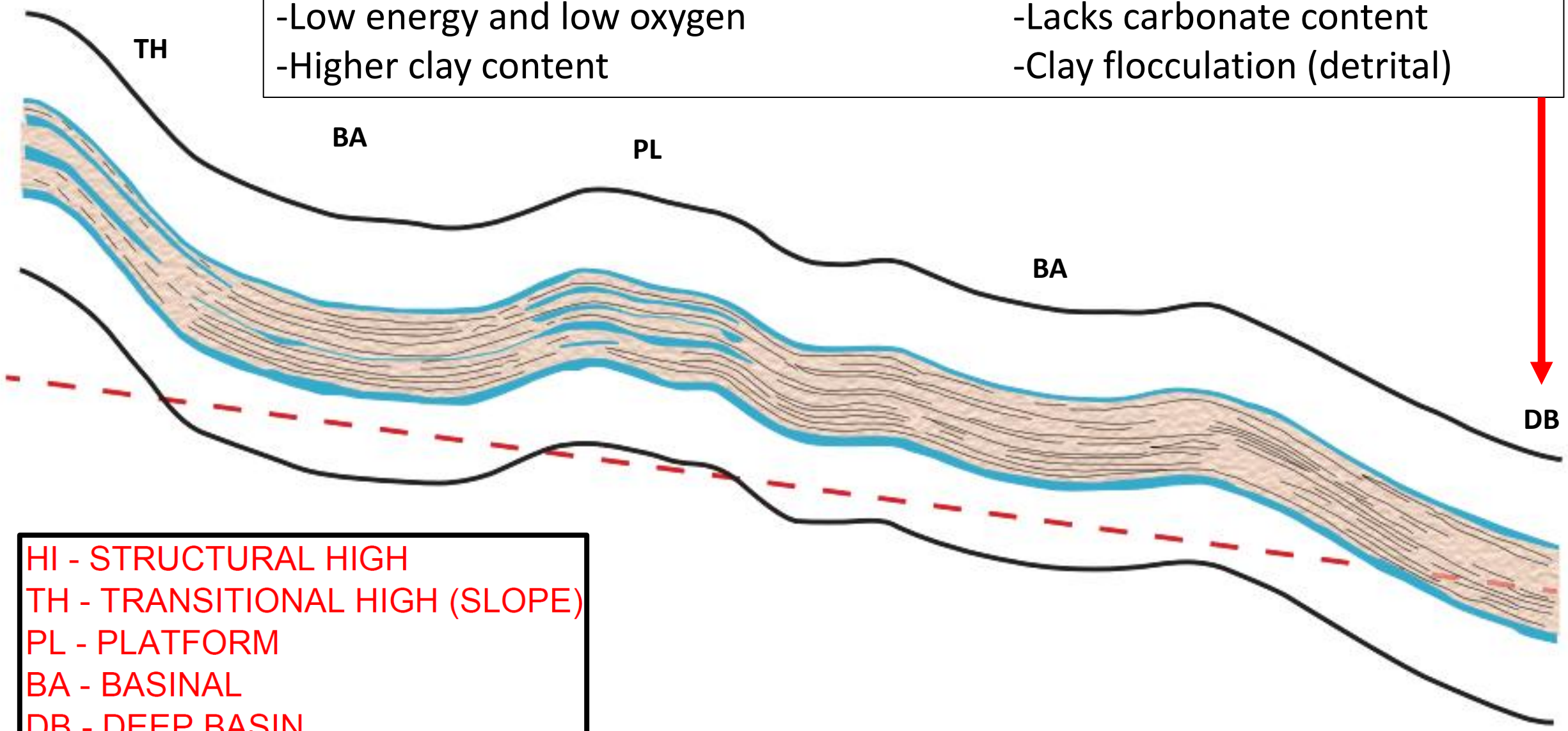
Deep Basin Setting

-Third best producing setting
-Low energy and low oxygen
-Higher clay content
-Below average production
-Lacks carbonate content
-Clay flocculation (detrital)



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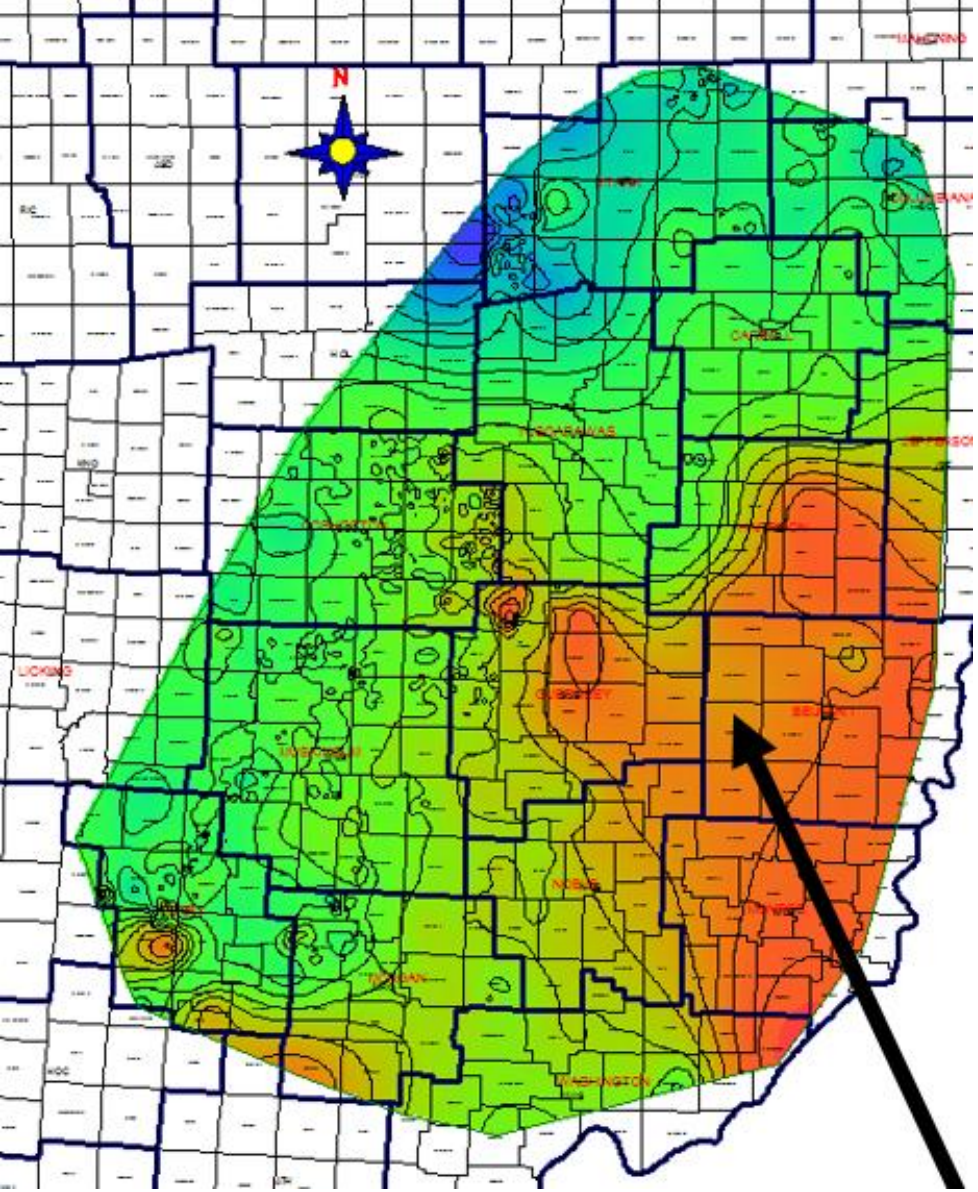
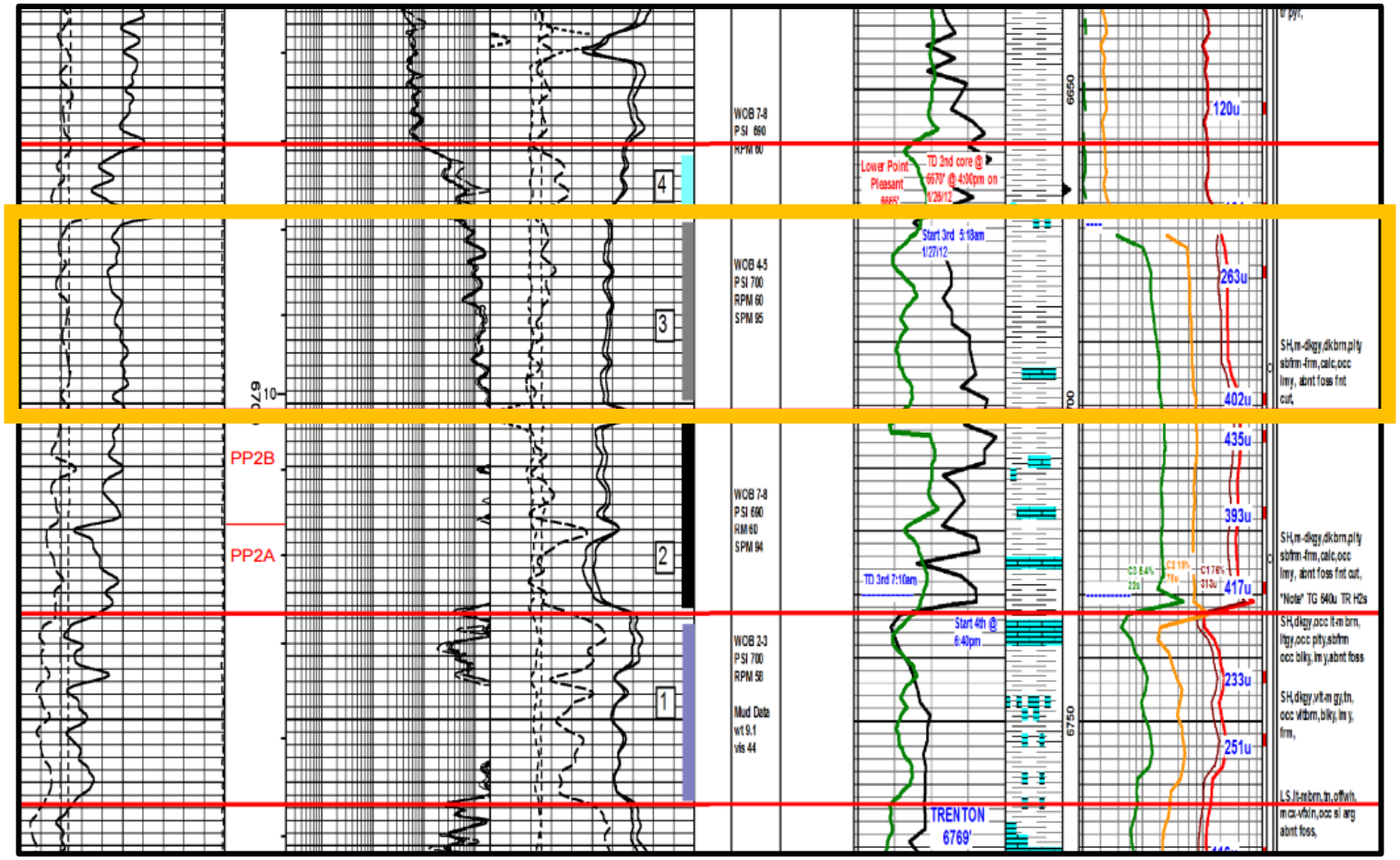
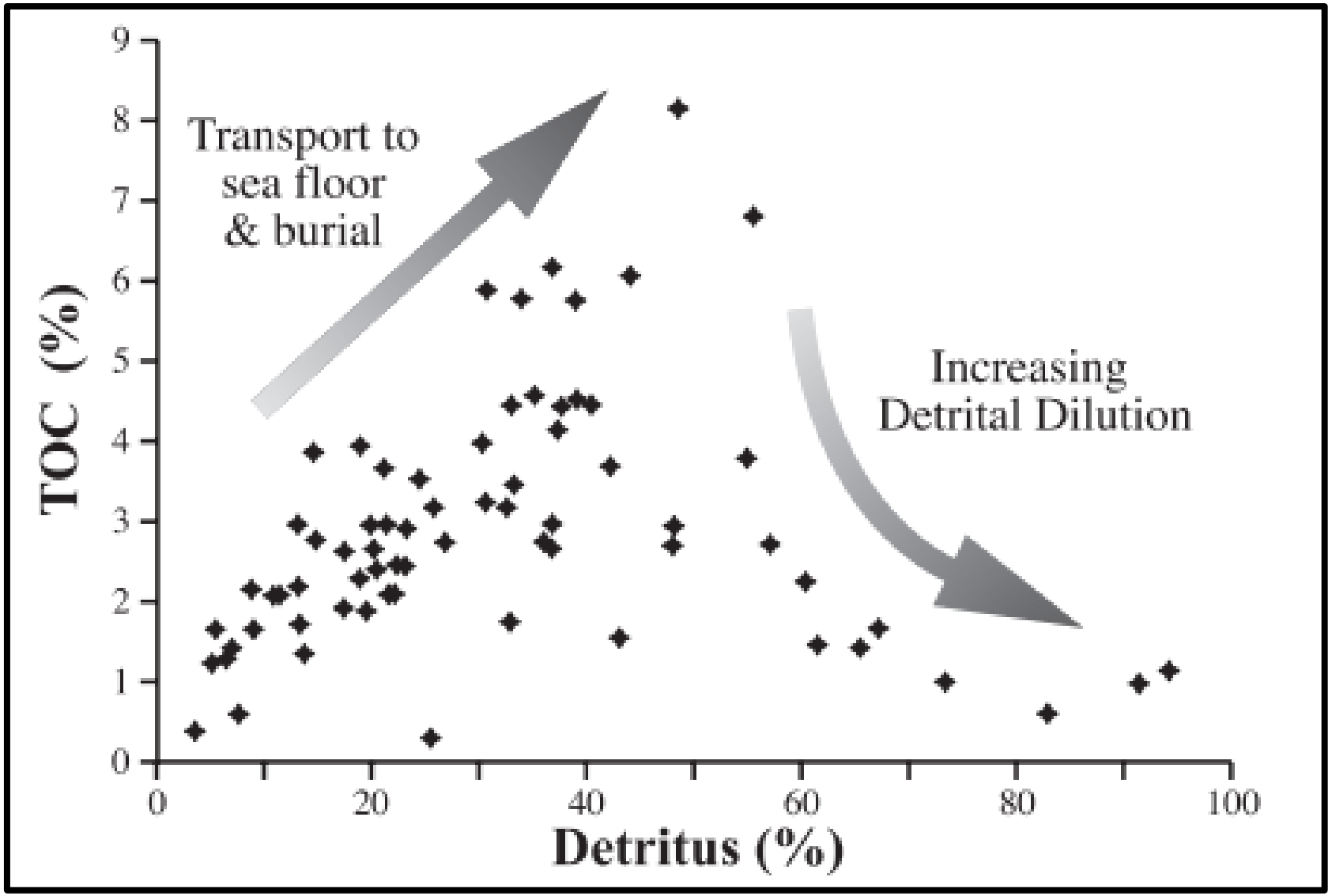




Siliciclastic prograding onto the craton

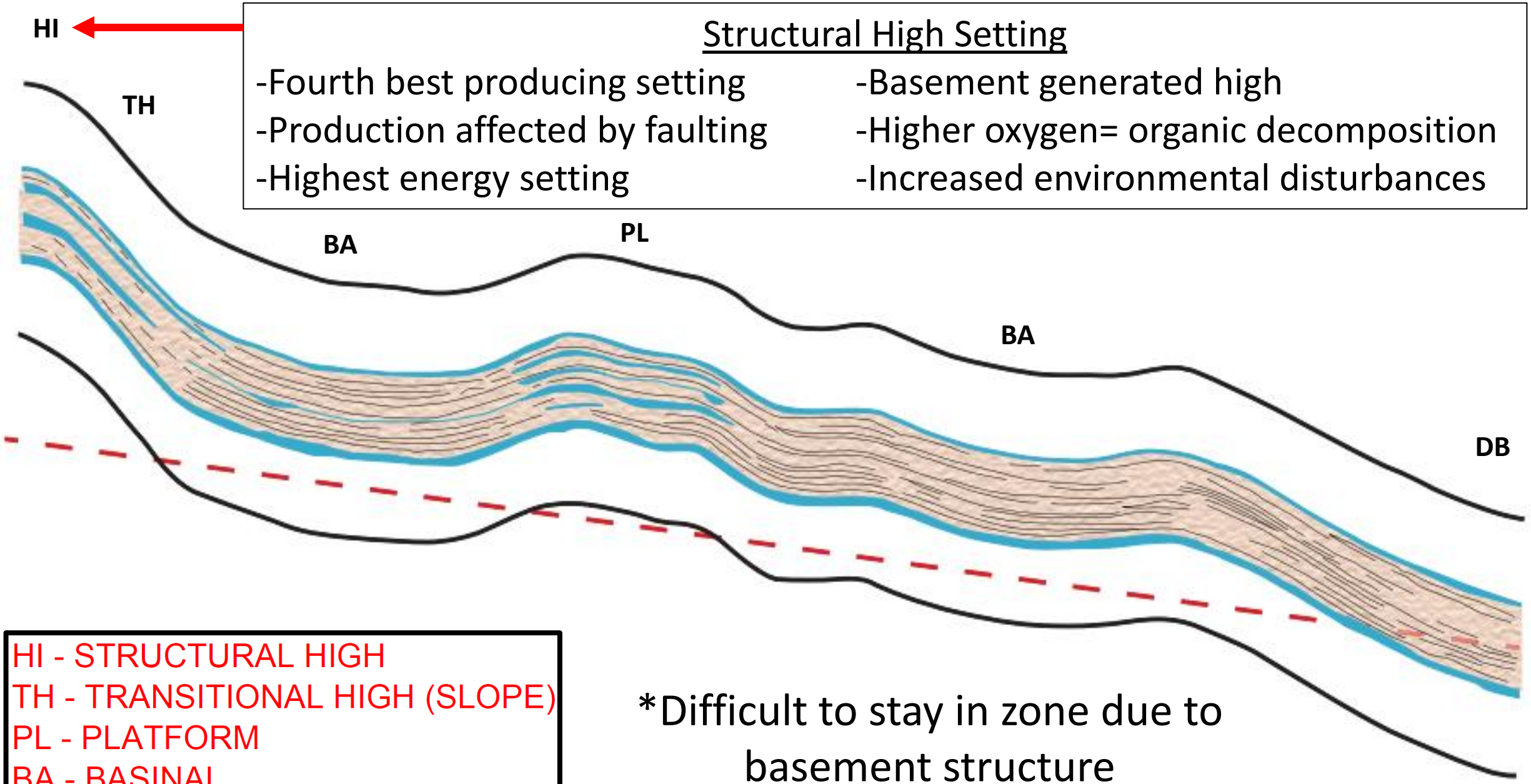
Point Pleasant Zone 3 Thickness

Detrital clays and siliciclastic mineral matter decrease the concentration of organic matter in the sediment (Bohacs, 1998).



Structural High Setting

- -Fourth best producing setting
- -Production affected by faulting
- -Highest energy setting
- -Basement generated high
- -Higher oxygen= organic decomposition
- -Increased environmental disturbances



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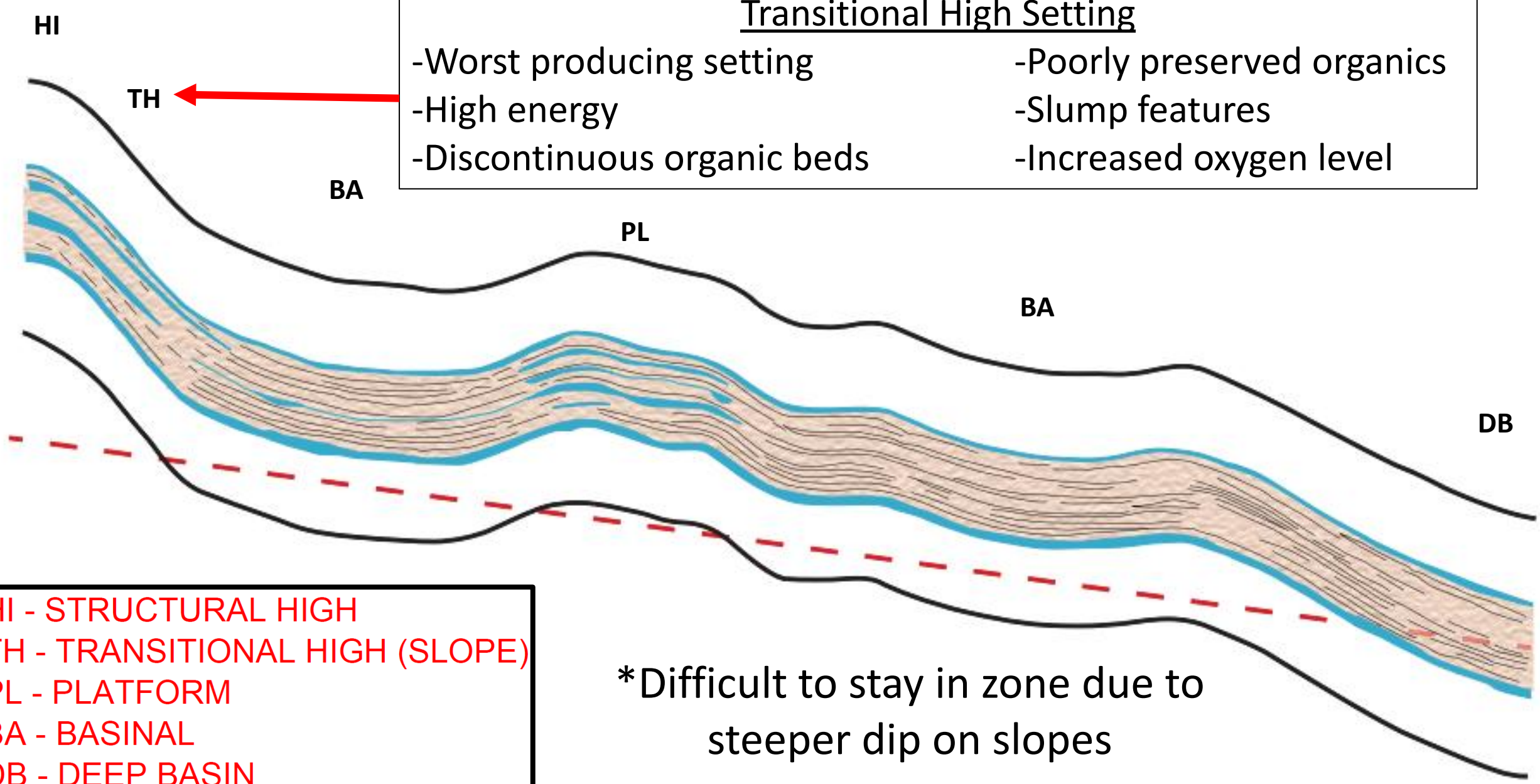
*Difficult to stay in zone due to basement structure

Transitional High Setting

- -Worst producing setting
- -High energy
- -Discontinuous organic beds
- -Poorly preserved organics
- -Slump features
- -Increased oxygen level



HI - STRUCTURAL HIGH
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*Difficult to stay in zone due to steeper dip on slopes

Summary & Geological Optimization

- Acreage is not equal across the Utica-Point Pleasant play

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- Poorer well performance is associated with wells placed on or near basement-generated highs and associated sloping features

Summary & Geological Optimization

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- Higher well performance is associated with wells placed in Basinal and Platform areas
- Poorer well performance is associated with wells placed on or near basement-generated highs and associated sloping features
- Wellbore placement (staying in the target zone) is also critical to well performance, and is more difficult in structurally complex areas near highs and sloping features

Summary & Geological Optimization

- Acreage is not equal across the Utica-Point Pleasant play
- Higher well performance is associated with wells placed in Basinal and Platform areas
- Poorer well performance is associated with wells placed on or near basement-generated highs and associated sloping features
- Wellbore placement (staying in the target zone) is also critical to well performance, and is more difficult in structurally complex areas near highs and sloping features
- Unconventional exploration and development can be significantly improved by identifying localized structures with residual mapping and 3D seismic, and then proper placement within optimal geological setting

Special Thanks

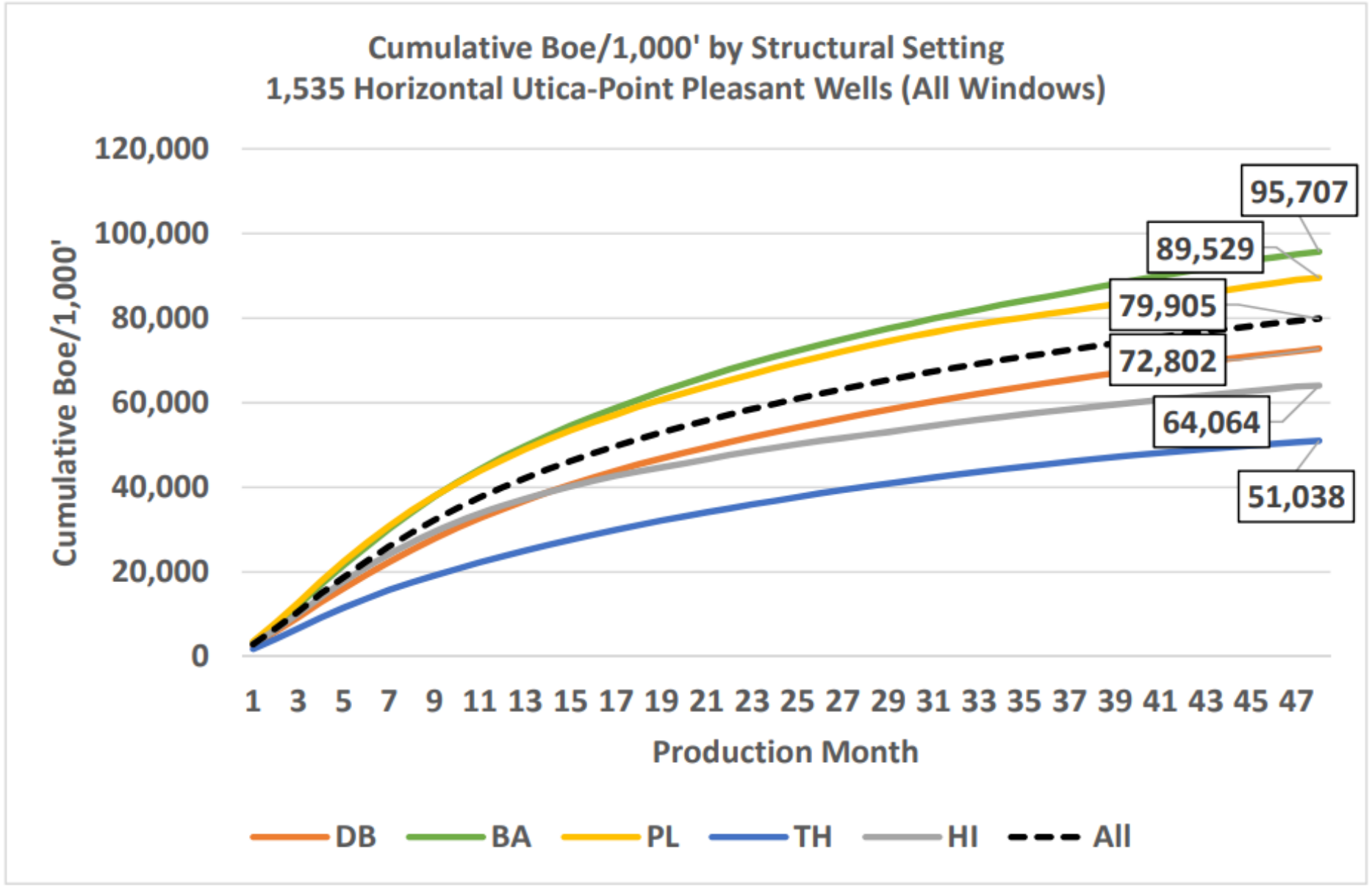
- EMF Geological Technicians

- Mike Brannock, CPG-Geologist, Brannock Resources

- Joe Brooker-Artex Energy Group LLC

- Dr. Greg Nadon Ohio University

Questions?


Cumulative Boe/1,000' by Structural Setting
1,535 Horizontal Utica-Point Pleasant Wells (All Windows)
Cumulative Boe/1,000'
120,000
100,000
80,000
60,000
40,000
20,000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Production Month
95,707
89,529
79,905
72,802
64,064
51,038
DB
BA
PL
TH
HI
All