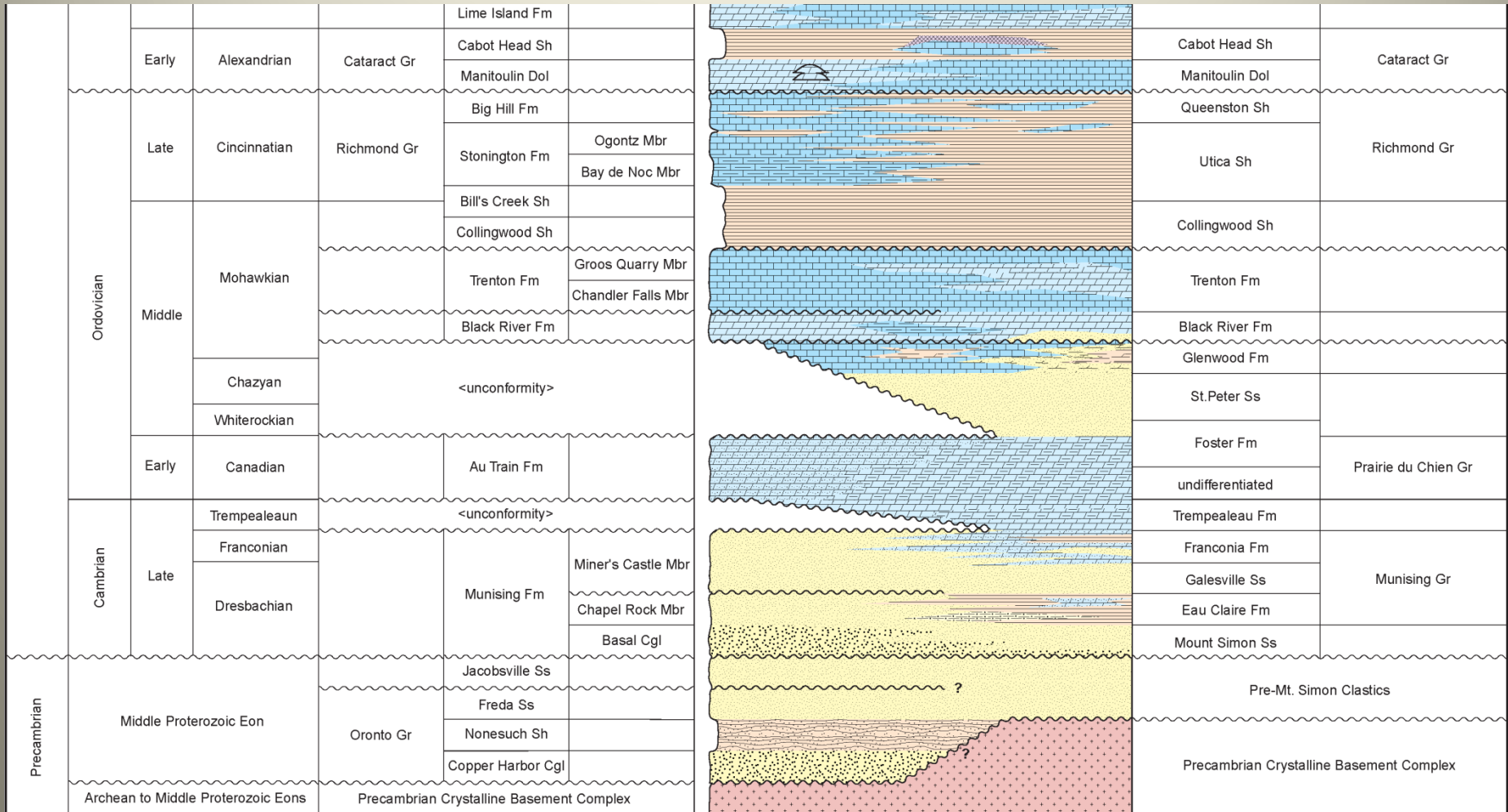


TRENTON-BLACK RIVER HYDROTHERMAL RESERVOIRS OF THE MICHIGAN BASIN

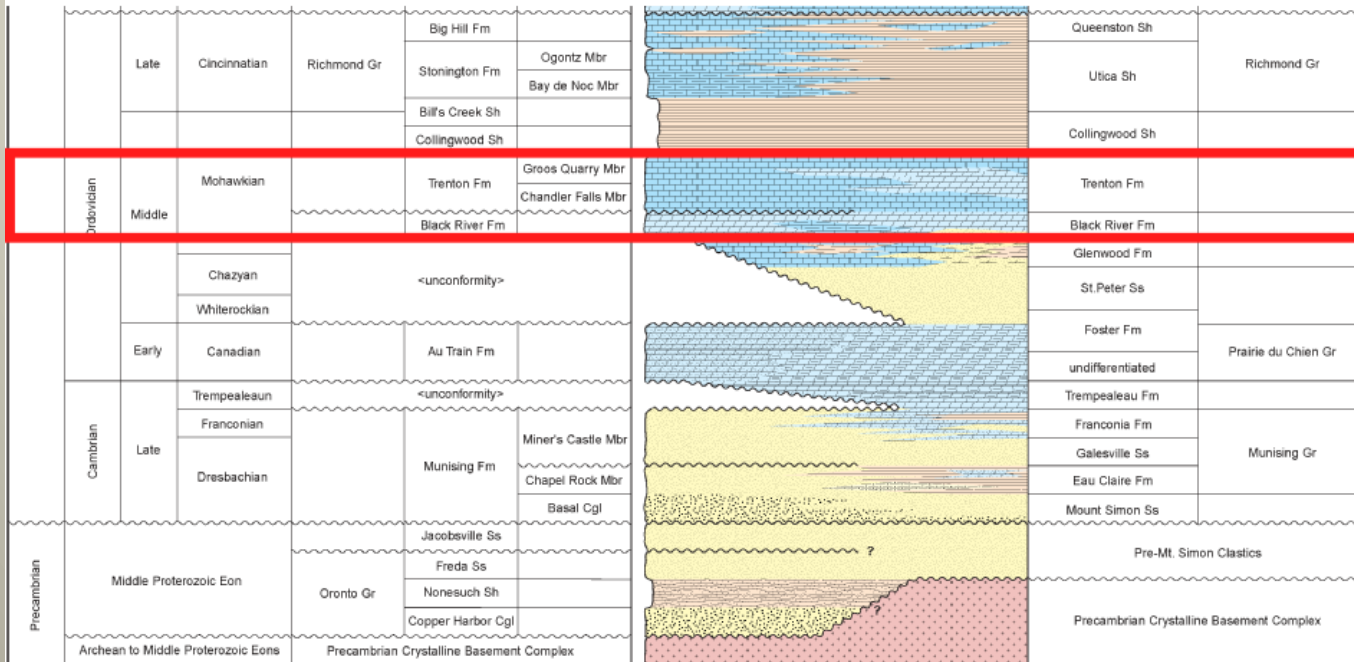
Bill Van Sickle – Michigan

**West Bay
Exploration**
company

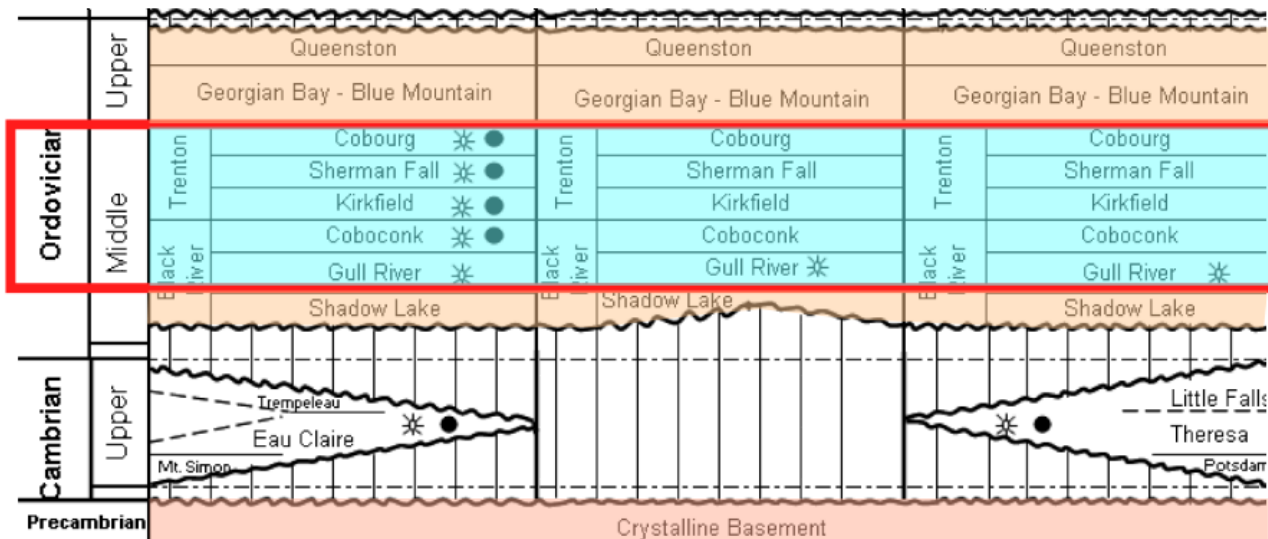
Stratigraphic Column - Michigan



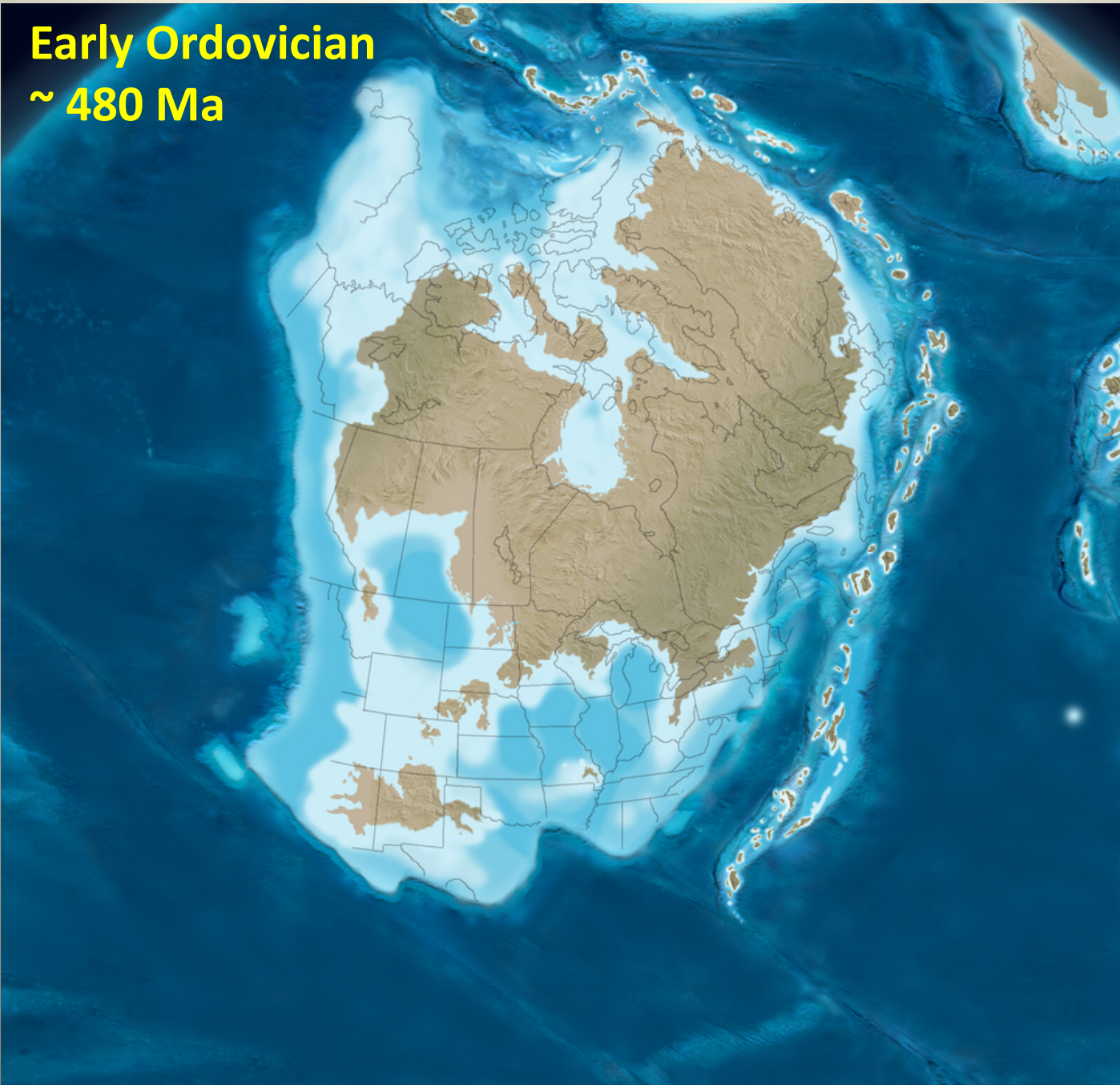
MICHIGAN

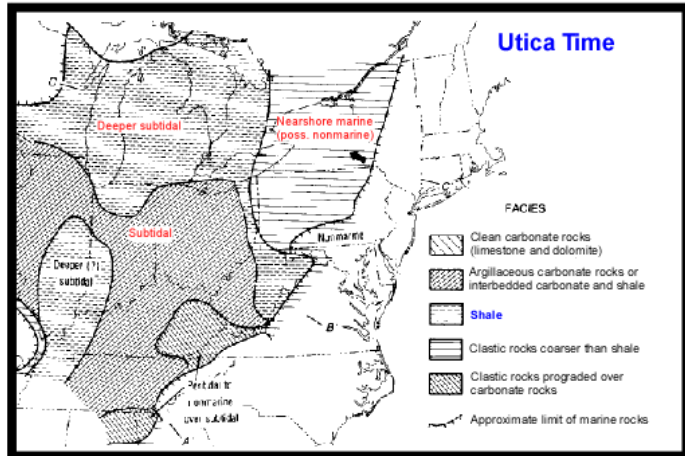
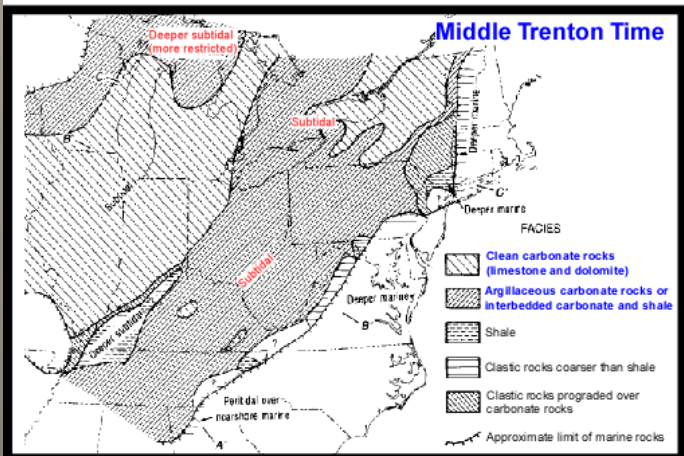
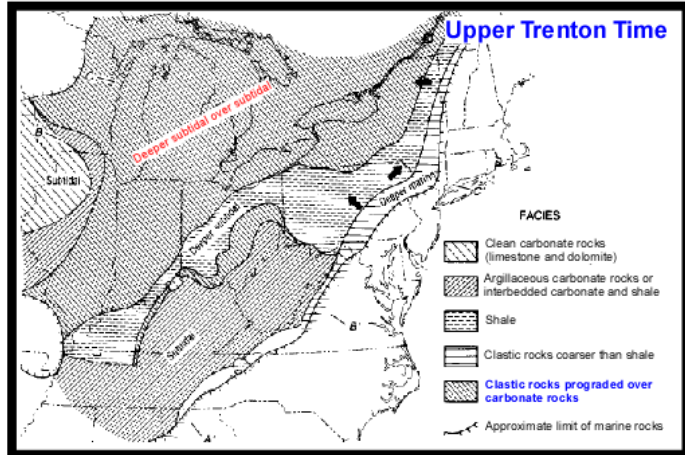
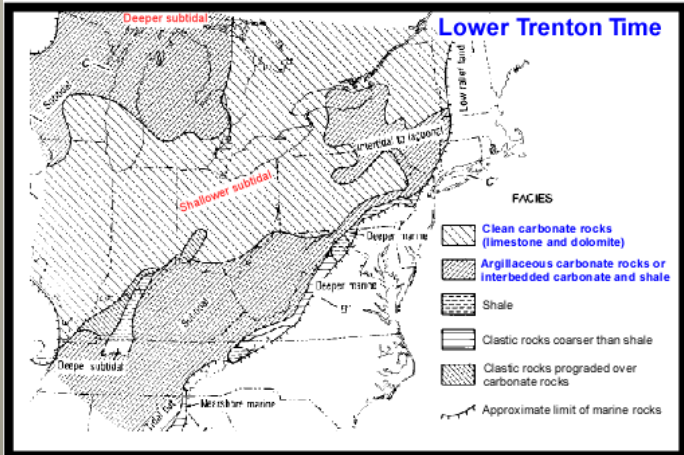
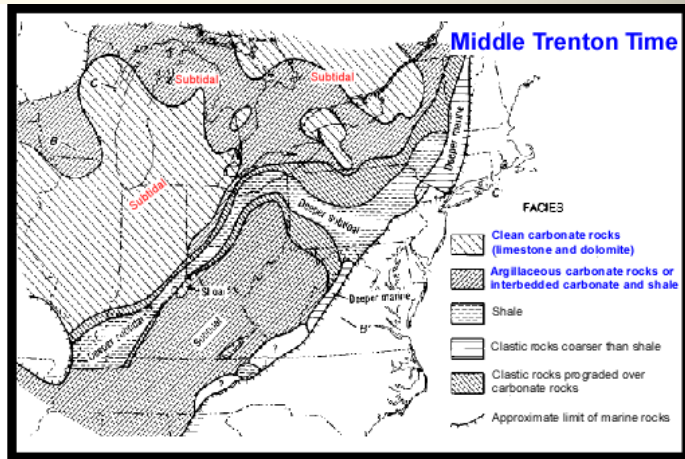
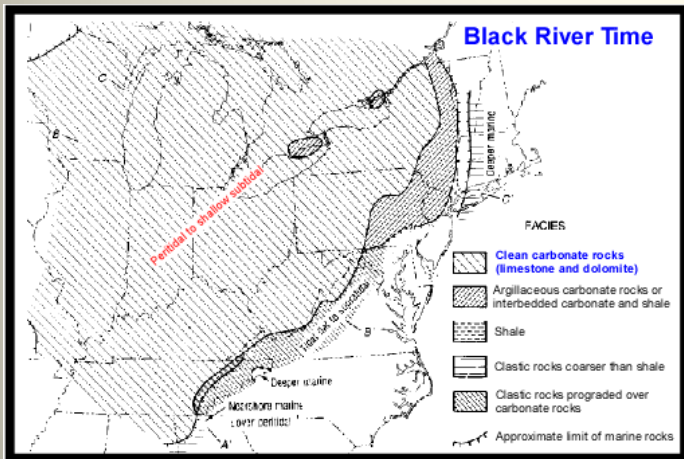


ONTARIO

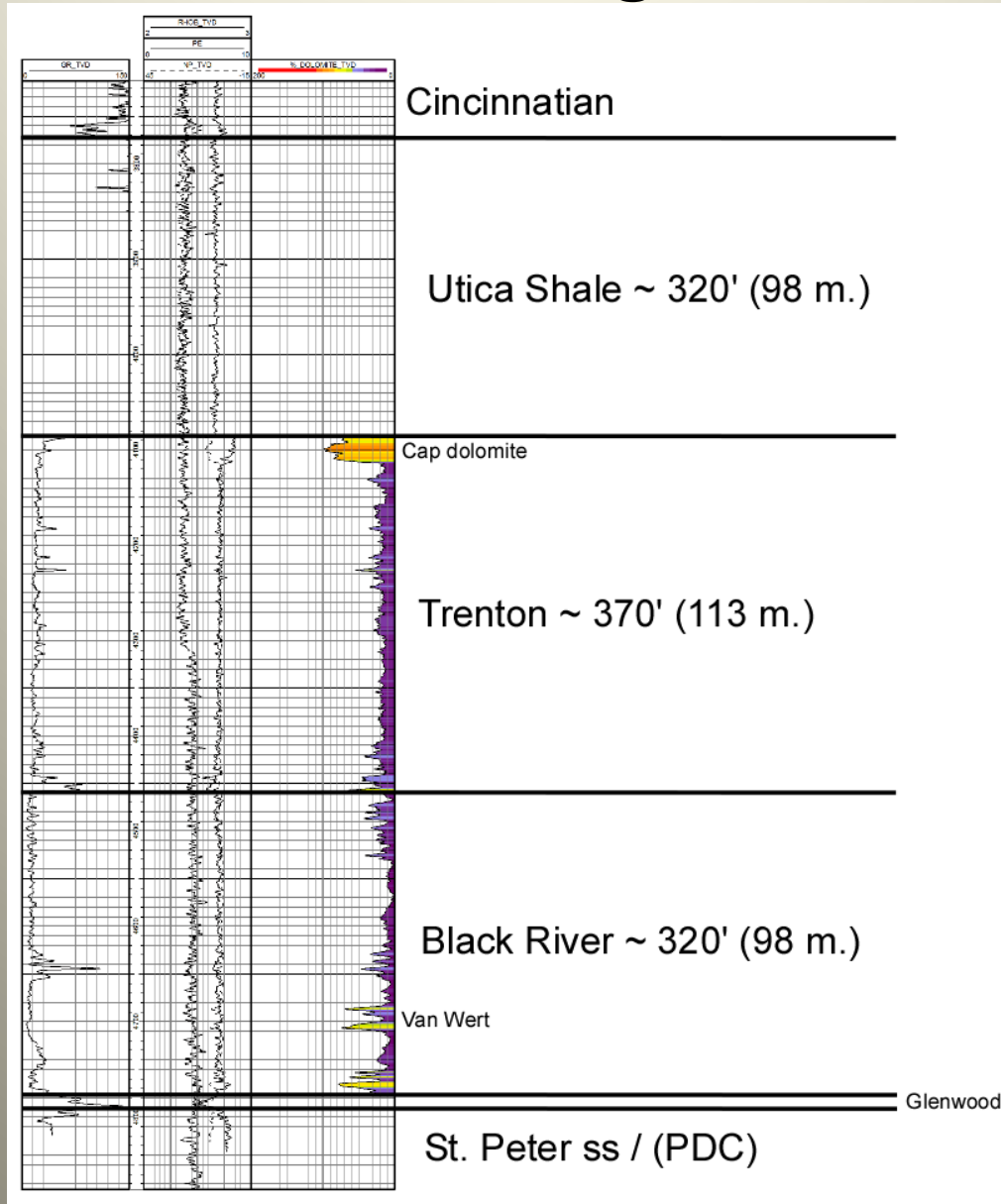


Early Ordovician
~ 480 Ma





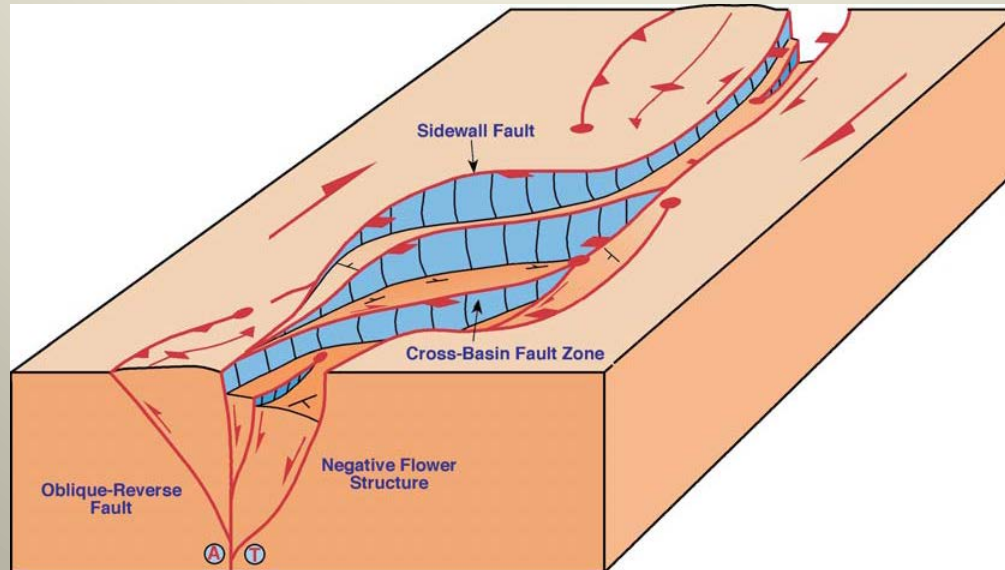
Regional Trenton-Black River S.E. Michigan



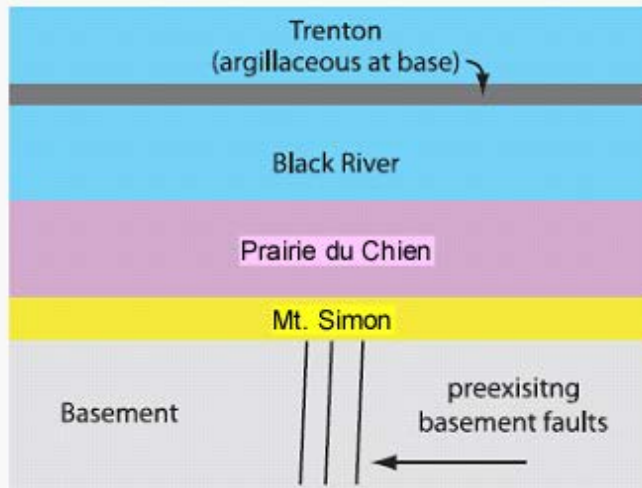
TRENTON-BLACK RIVER RESERVIOR

- Hydrothermal dolomite
- Seal – Utica shale (vertical), Tight limestone (lateral)
- Formed by transtensional stress on existing basement faults during Taconic Orogeny
- Chaotic mix of fractured dolomite/limestone with varying degrees of vugular and matrix porosity
- Solution Gas Drive
- ***EVERY WELL IS DIFFERENT***

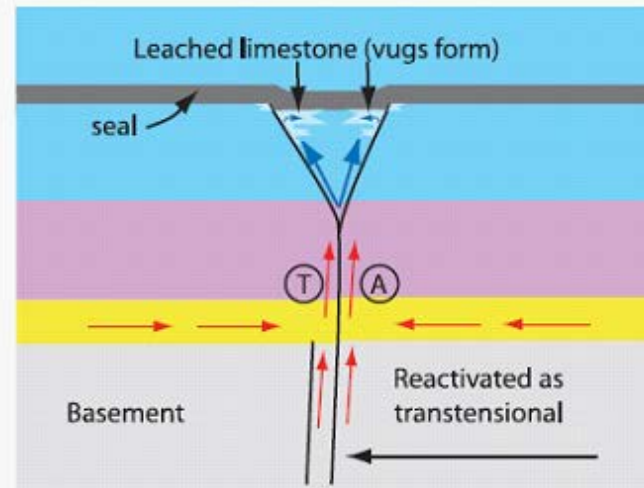
Transtensional Stress on existing basement faults during Taconic Orogeny



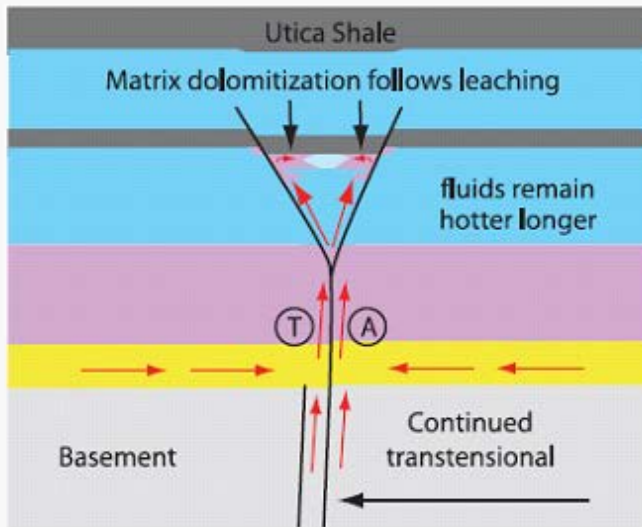
Linear series of extensional, left-lateral wrench faults



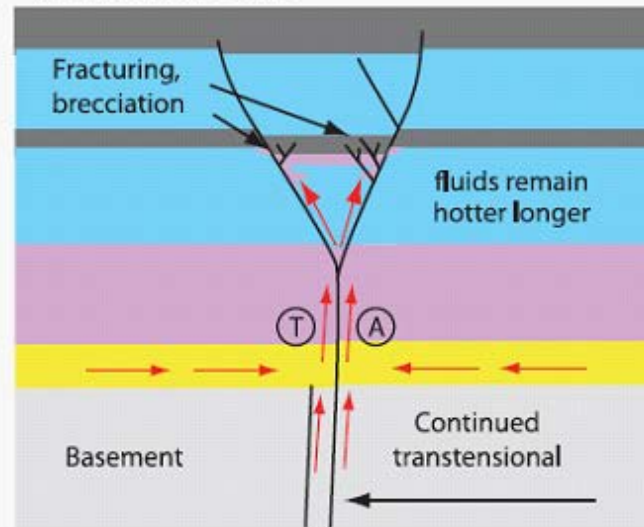
A) Trenton deposition



B) Onset of faulting (Trenton deposition), cooling fluids leach limestone



C) Faulting continues (Utica deposition); hotter fluids dolomitize leached matrix



D) Faulting continues (Utica, later?); Matrix fractured, vugs, breccias and fractures filled with saddle, etc.

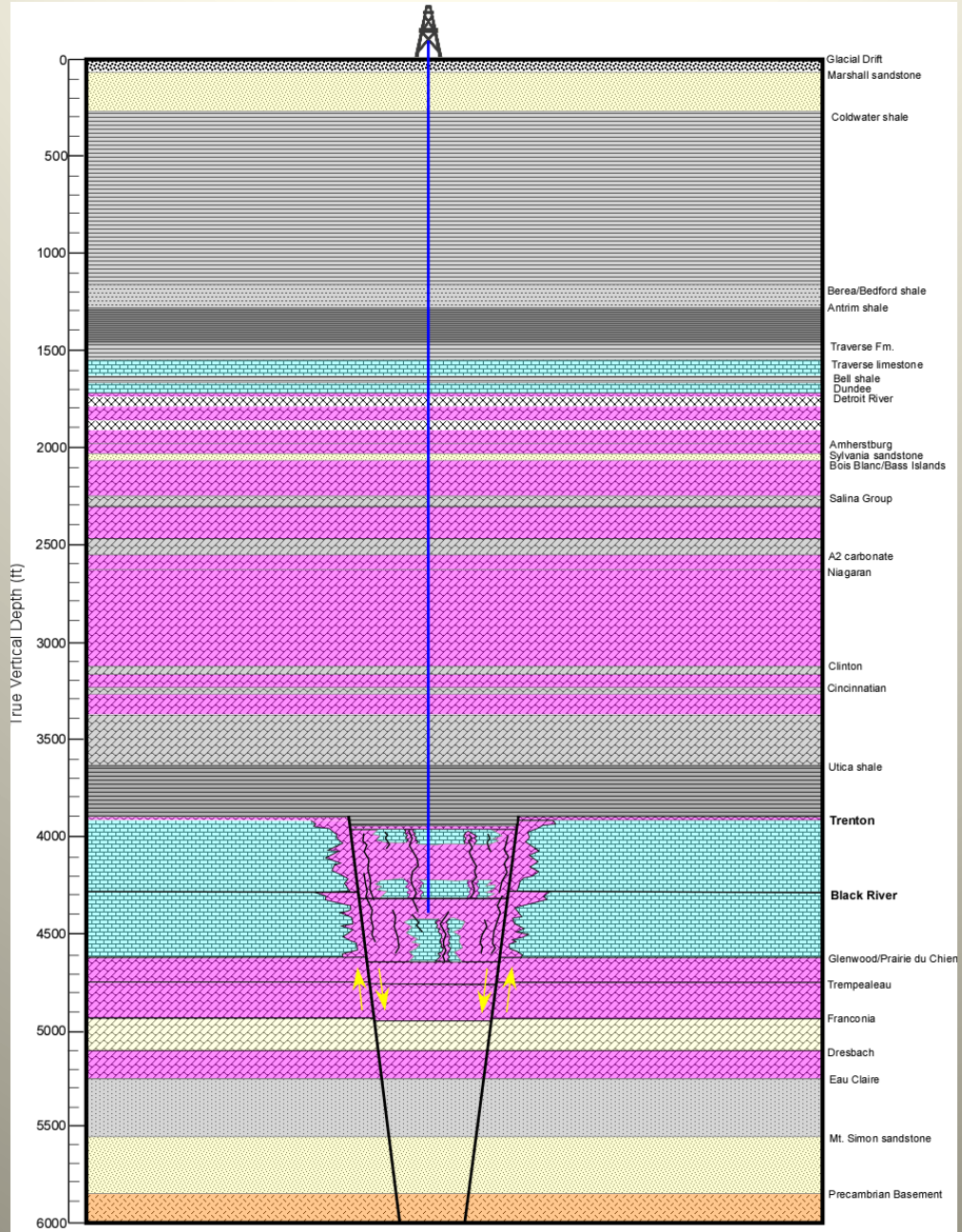
Shale
 Limestone
 Dolomite
 Sandstone

↗ hot Fluid Flow
↖ cooling Fluid Flow

T Strike-Slip Toward
A Strike-Slip Away

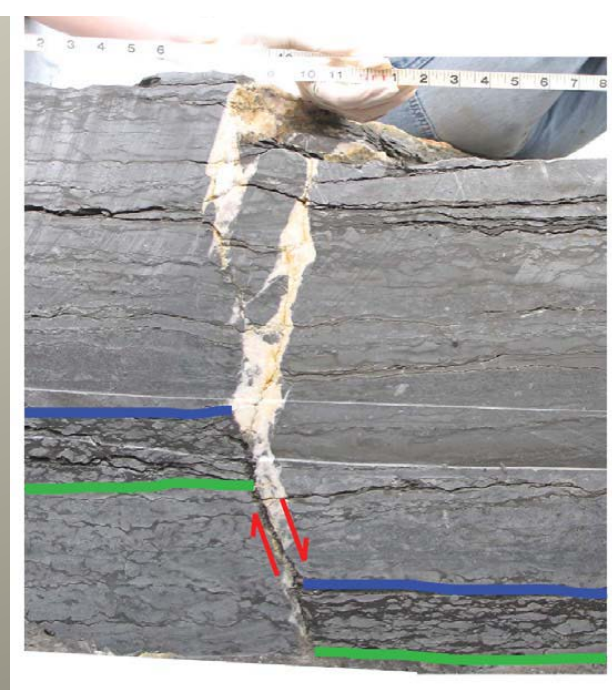
Hydrothermal Fluid Migration

- **Flow along path of least resistance**
- **Controlling Factors : Faults, fractures, shale barriers, bedding planes & facies**
- **These controls on porosity/permeability dictate where the hydrothermal fluids flow in both a vertical & horizontal directions.**



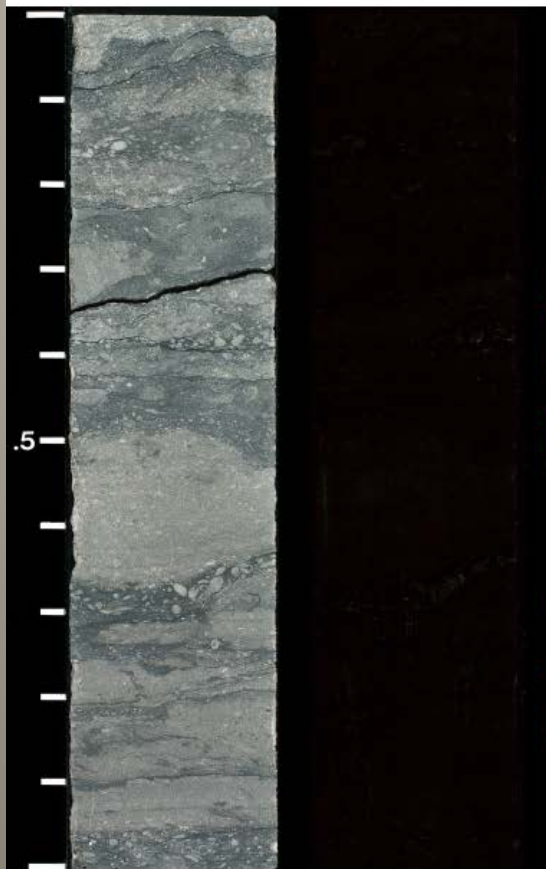
**Palatine Bridge Dolomite
Outcrop, Mohawk Valley, New
York**





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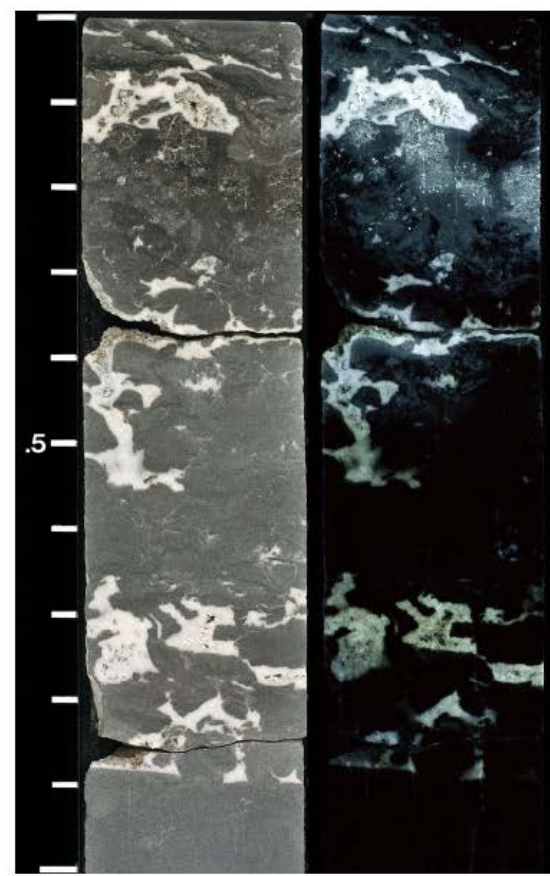
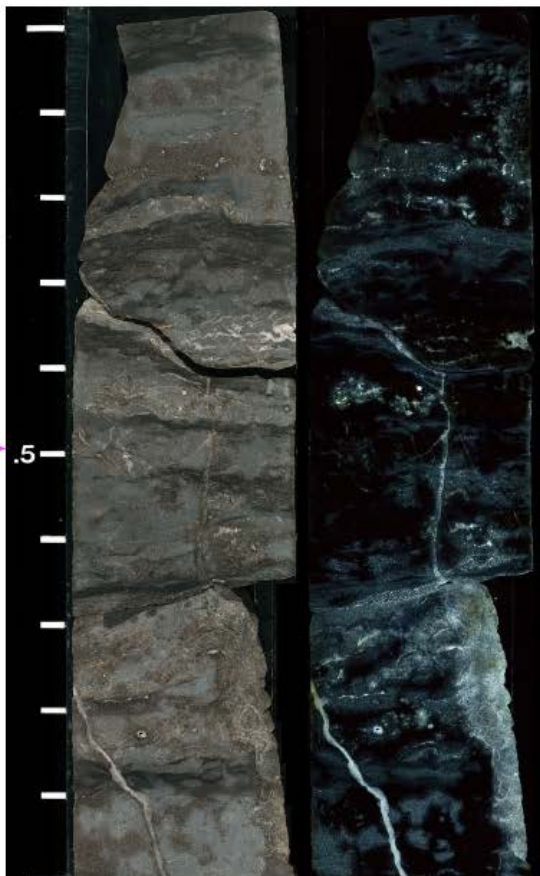
Regional Limestone



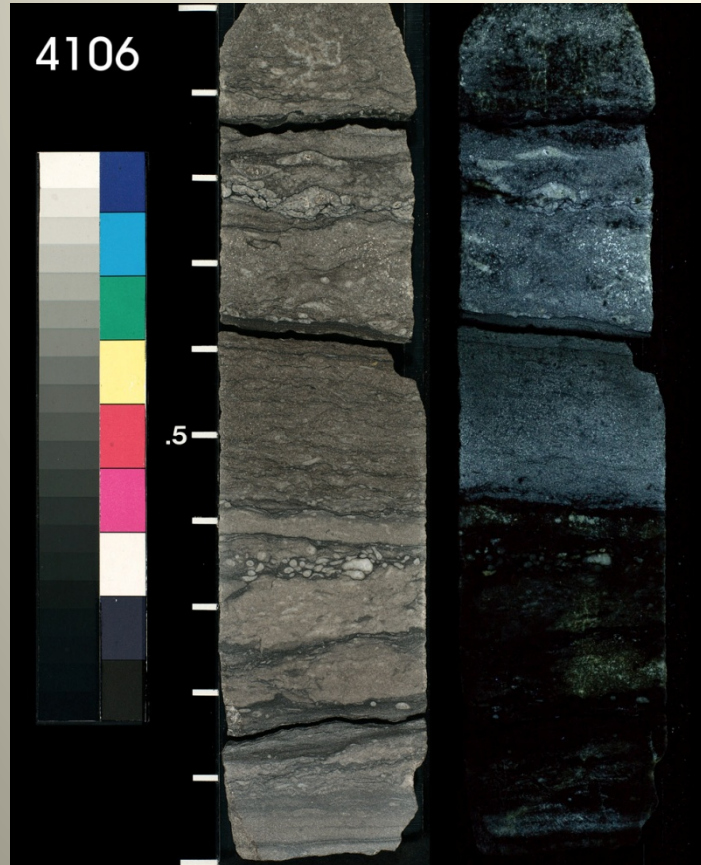
Hydrothermal Fluid Migration



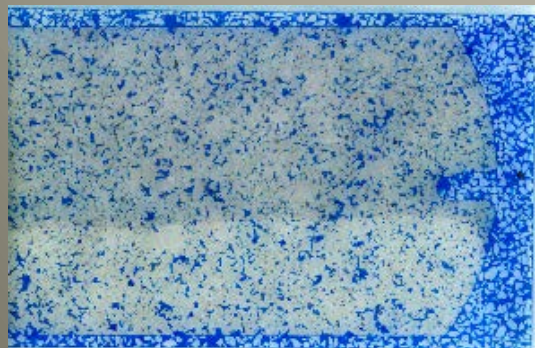
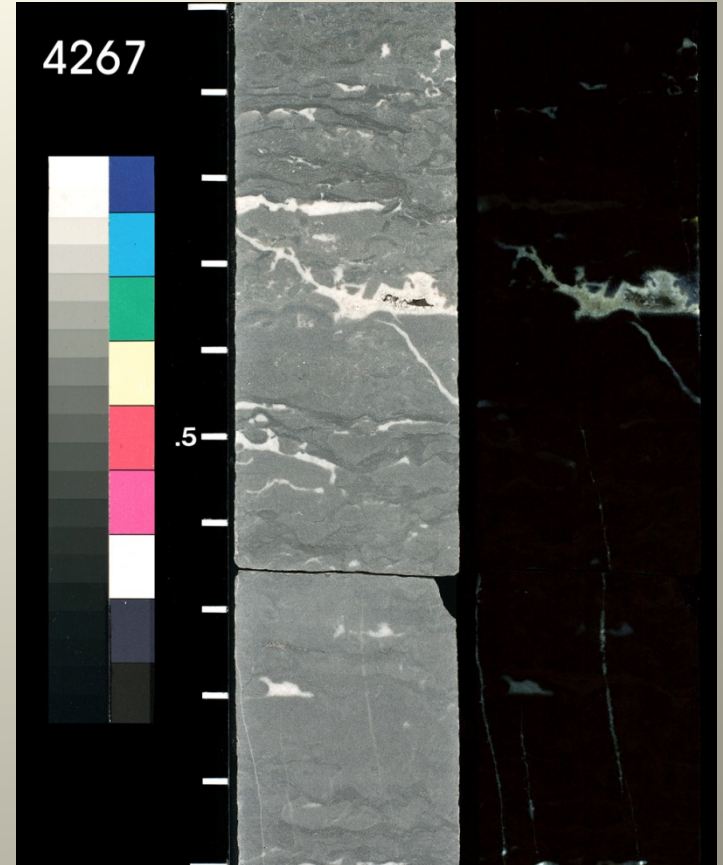
Hydrothermal Dolomite



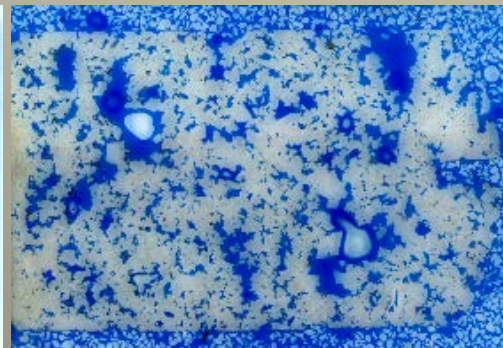
Matrix porosity



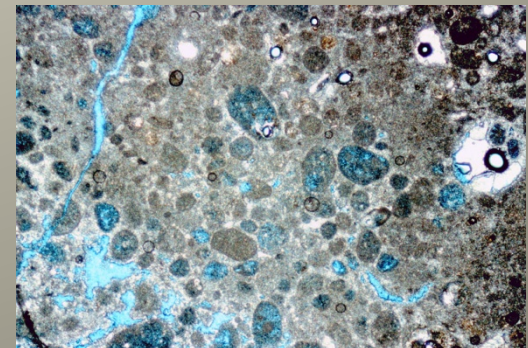
Fracture/Vugular porosity

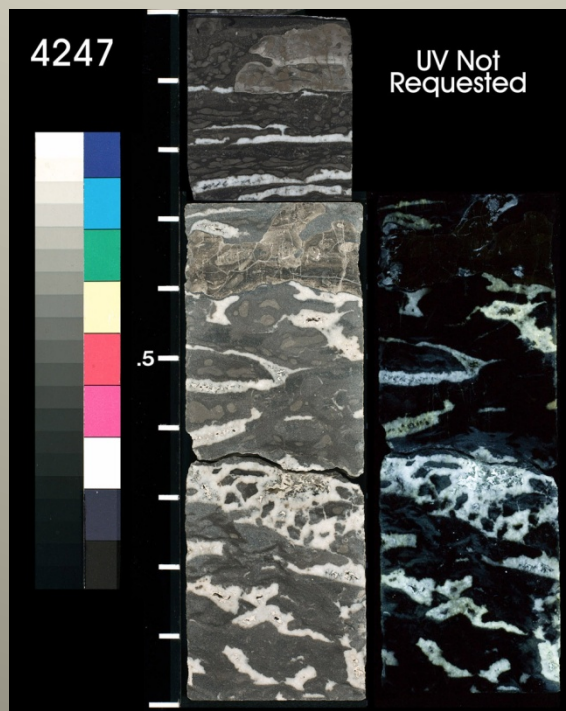
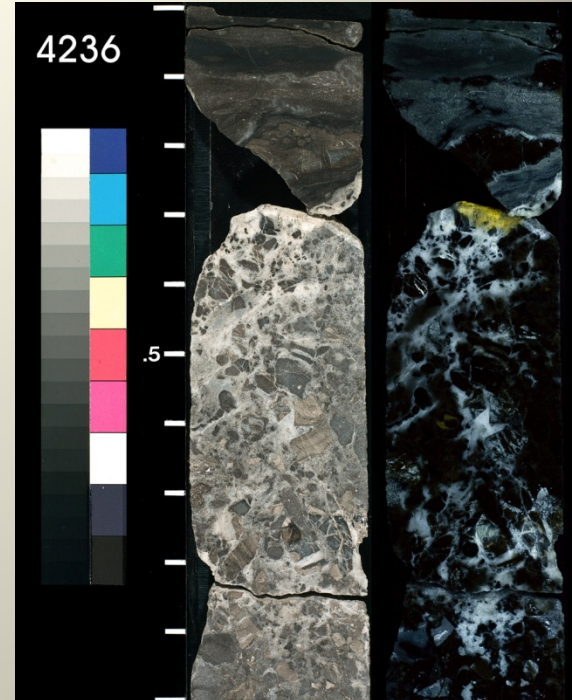
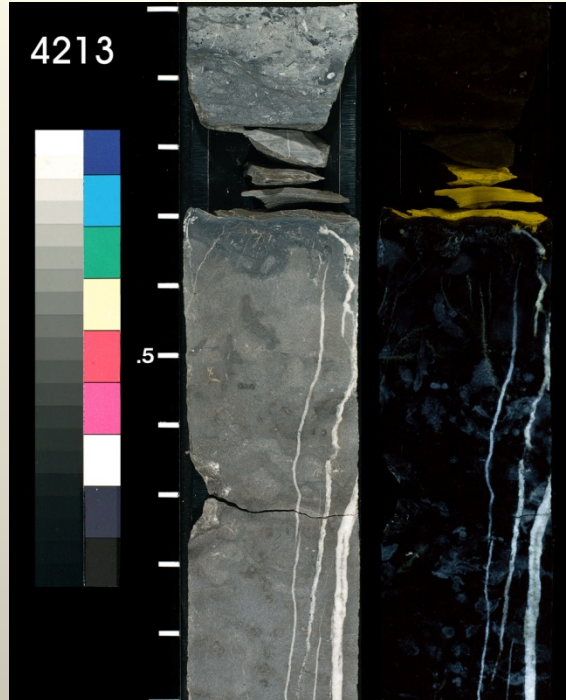
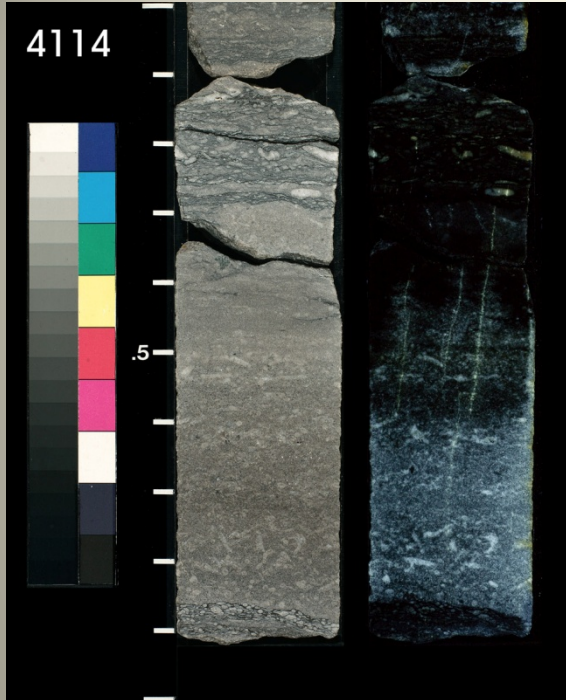


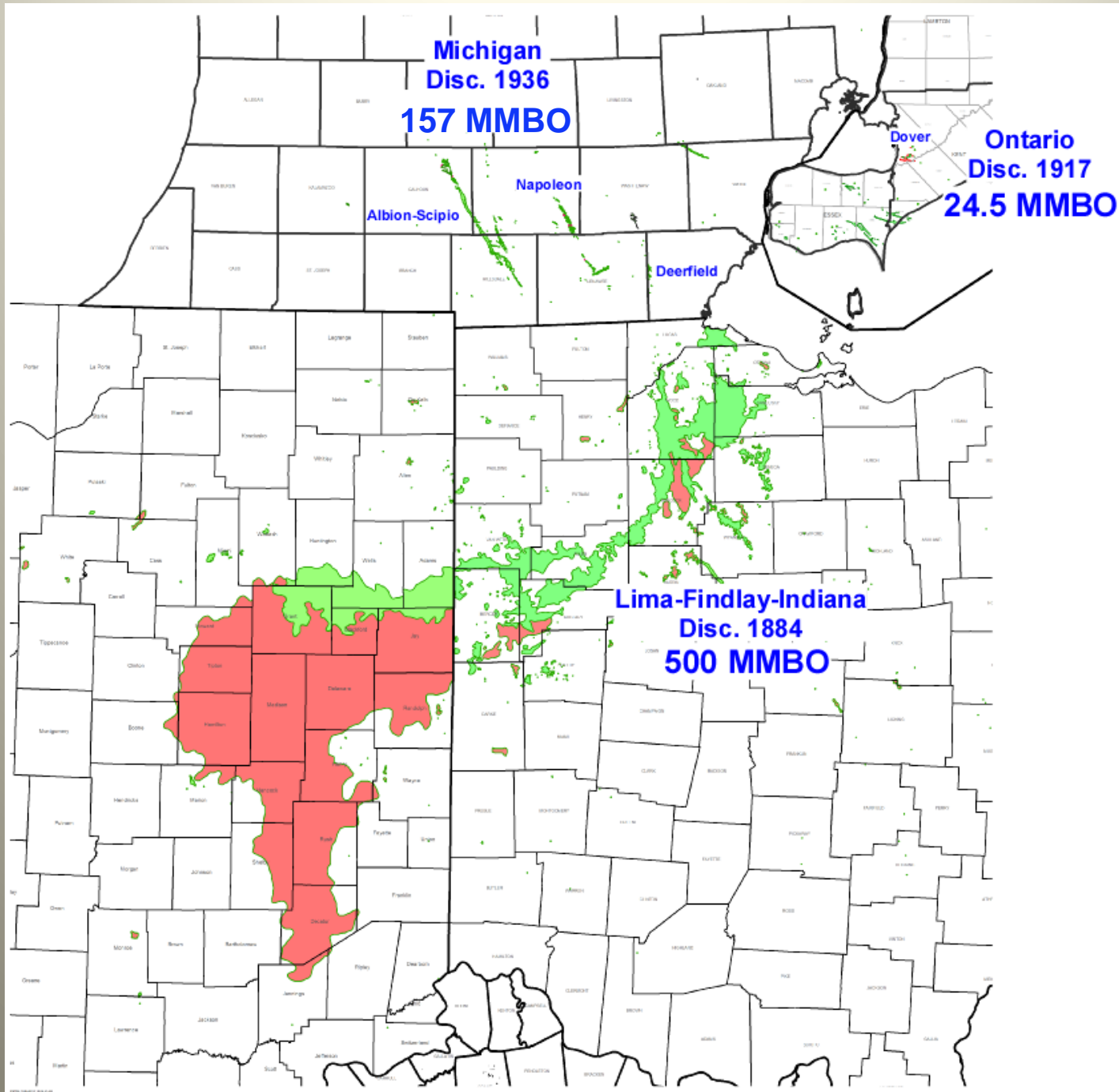
13%, 311 mD



16%, 2170 mD



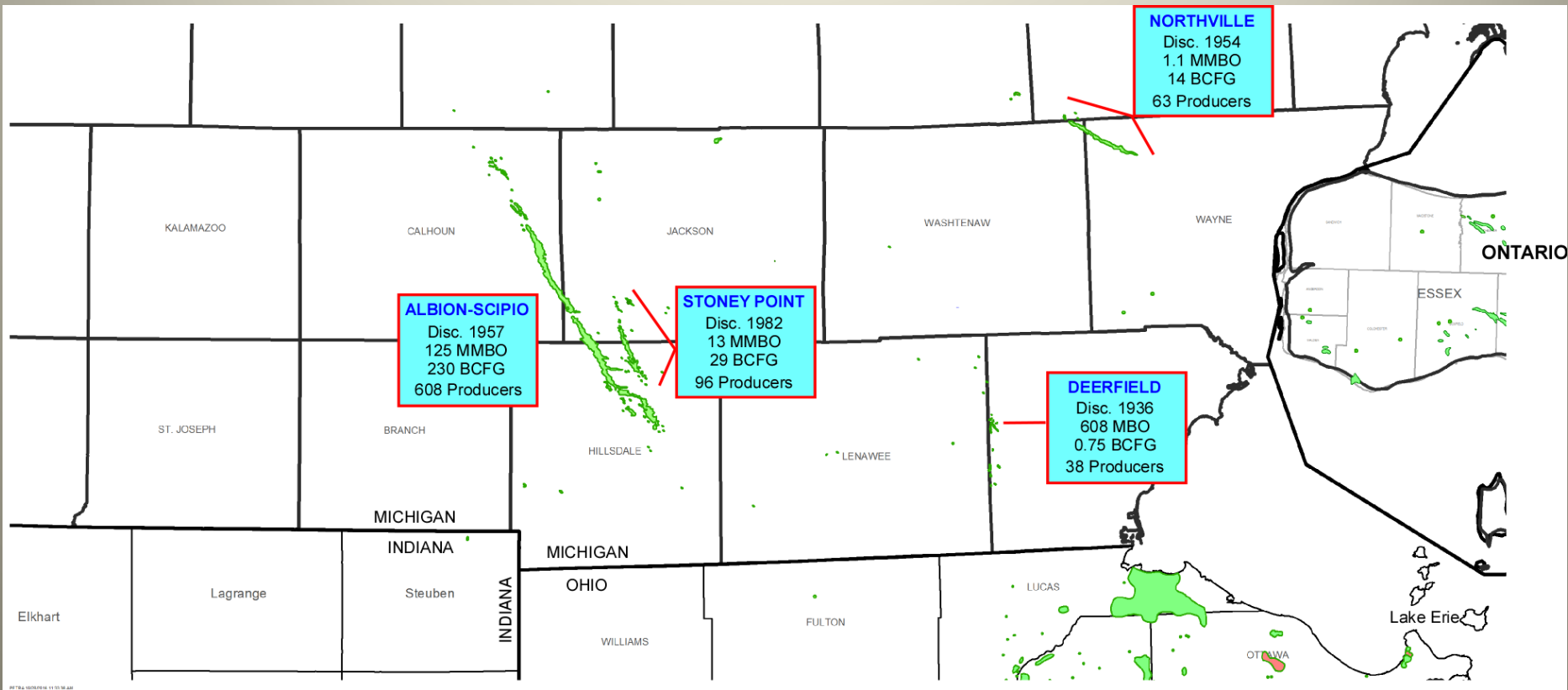




MICHIGAN

**TRENTON-BLACK RIVER
OIL & GAS FIELDS**

TRENTON-BLACK RIVER HISTORIC FIELDS S.E. MICHIGAN

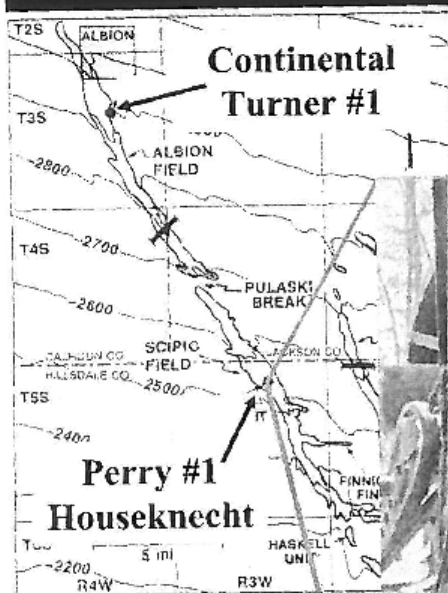


Discovery: Albion – Scipio Field

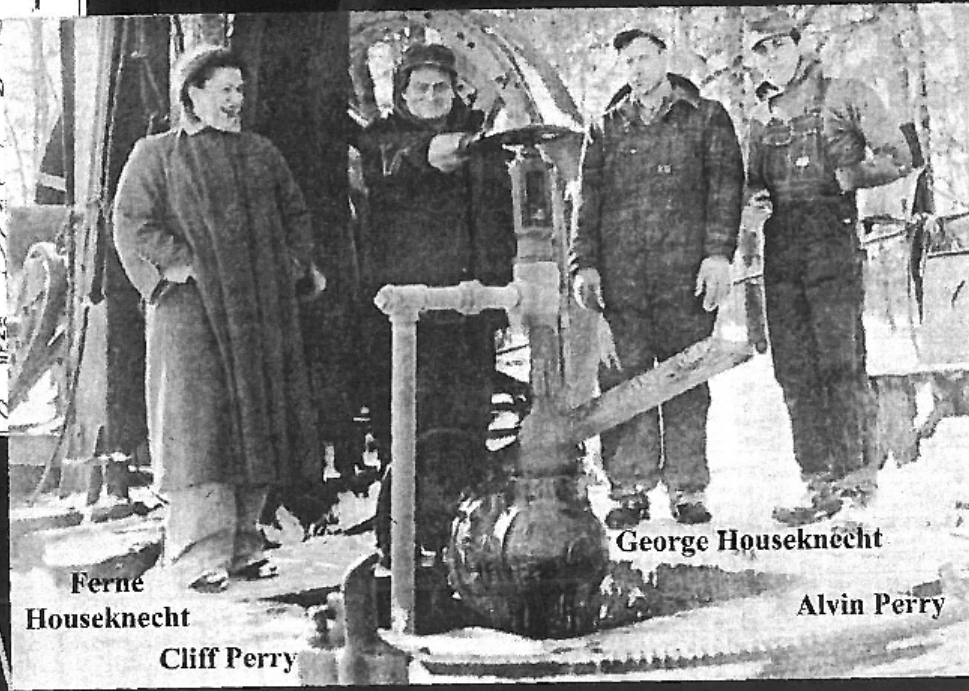
January 7, 1957

Discovery well

Perry #1 Houseknecht



Map:
Hurley and Budros, 1990
Photo:
Westbrook, 1993



1955 – Houseknecht #1

Originally drilled for Devonian gas – DRY

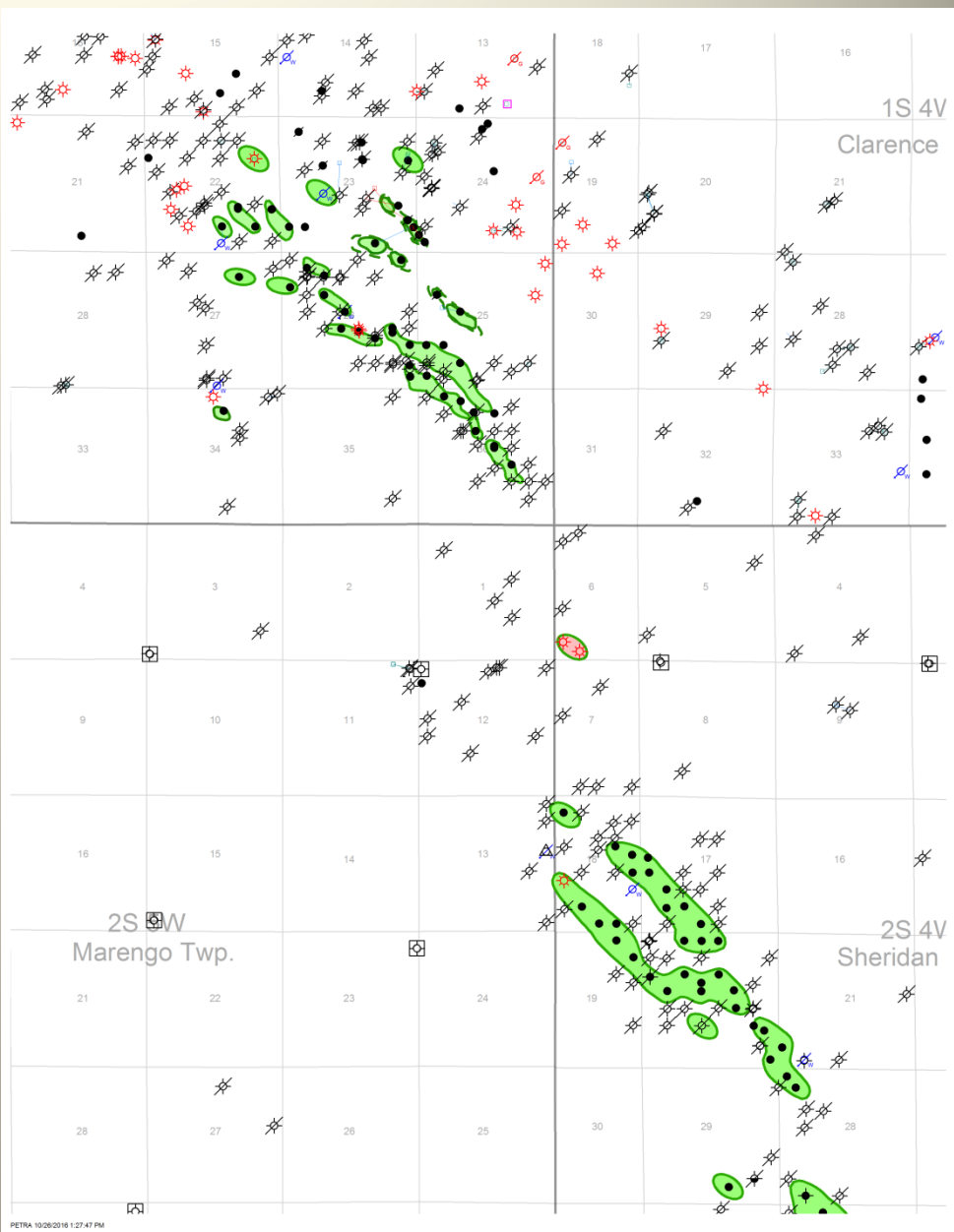
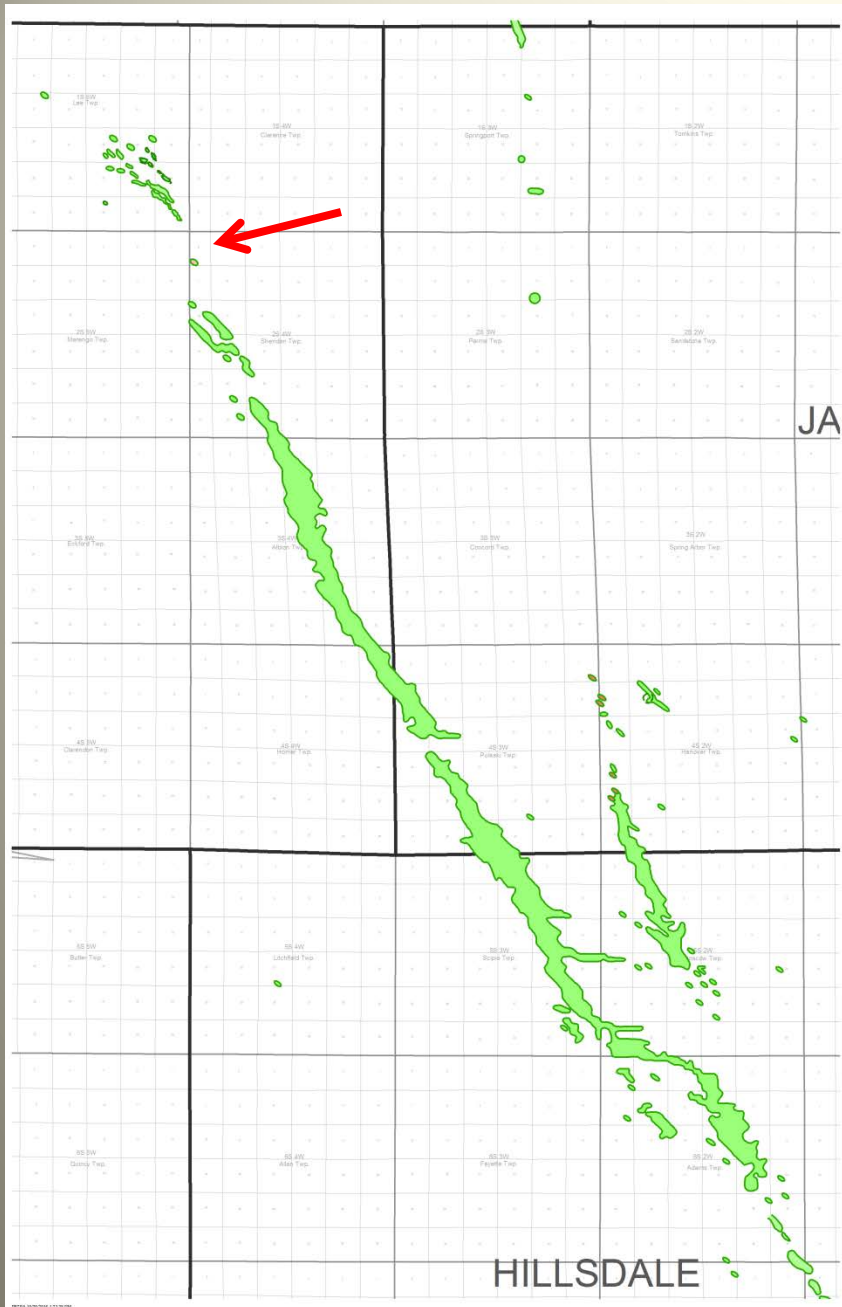
1957 – Deepened by advice of psychic friend

Encountered oil @ 3900' – 140 BOPD

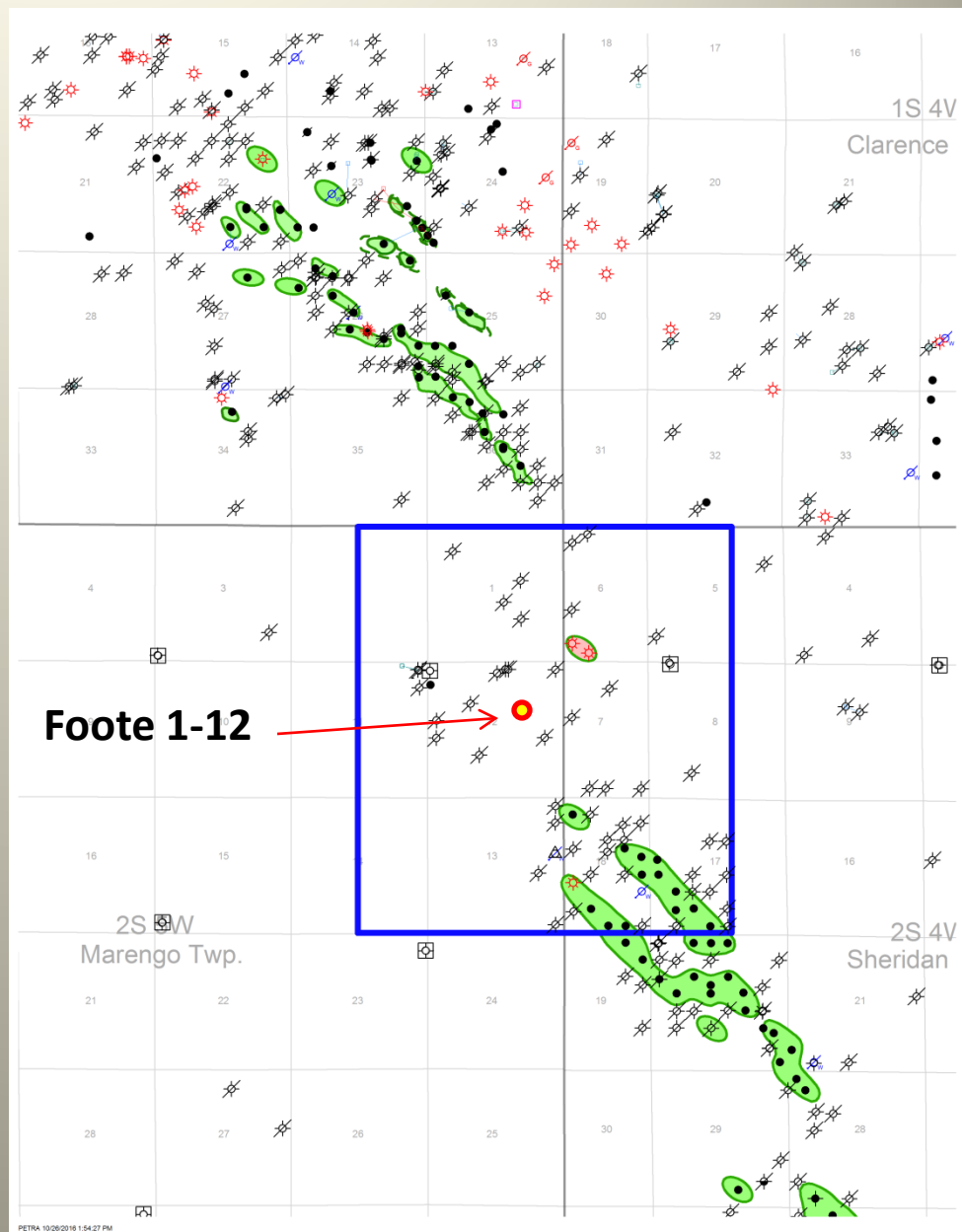
TRENTON-BLACK RIVER
RESURGENCE

RICE CREEK DISCOVERY
2006

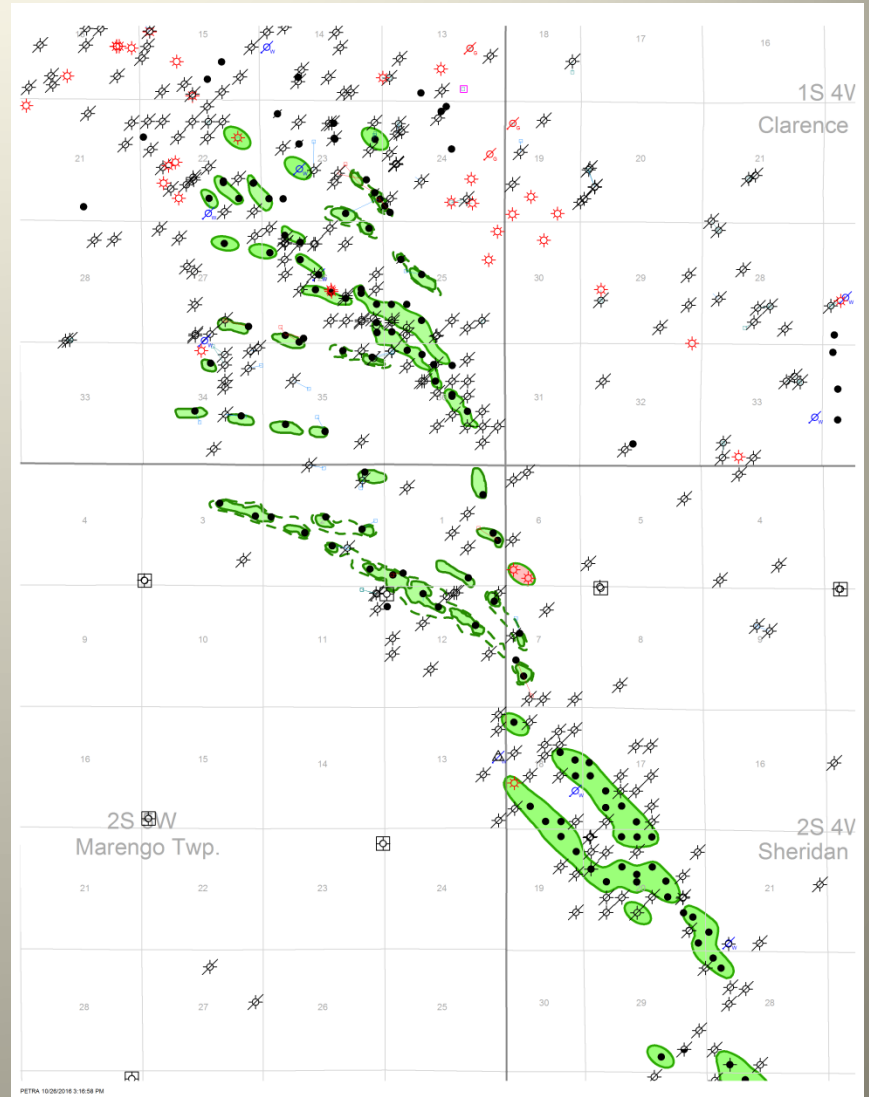
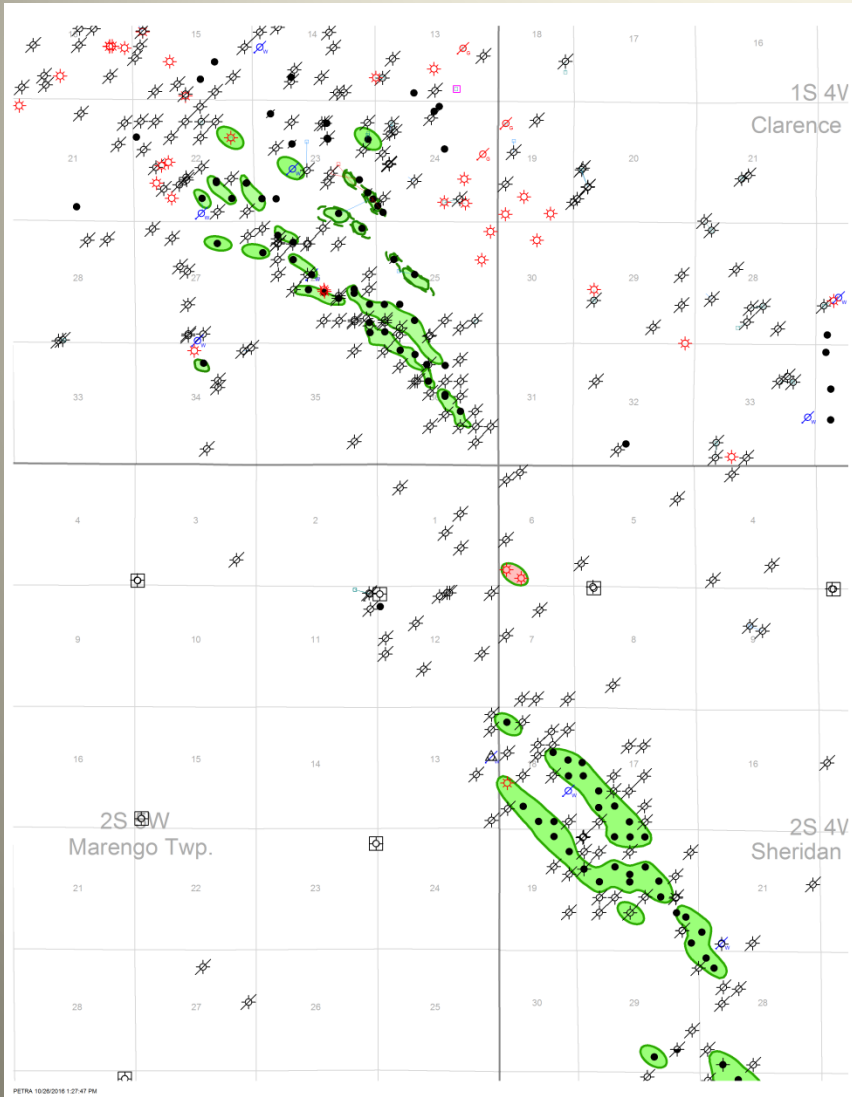
West Bay Exploration Co.



West Bay programmed and shot a 7 ½ mi² 3-D seismic survey



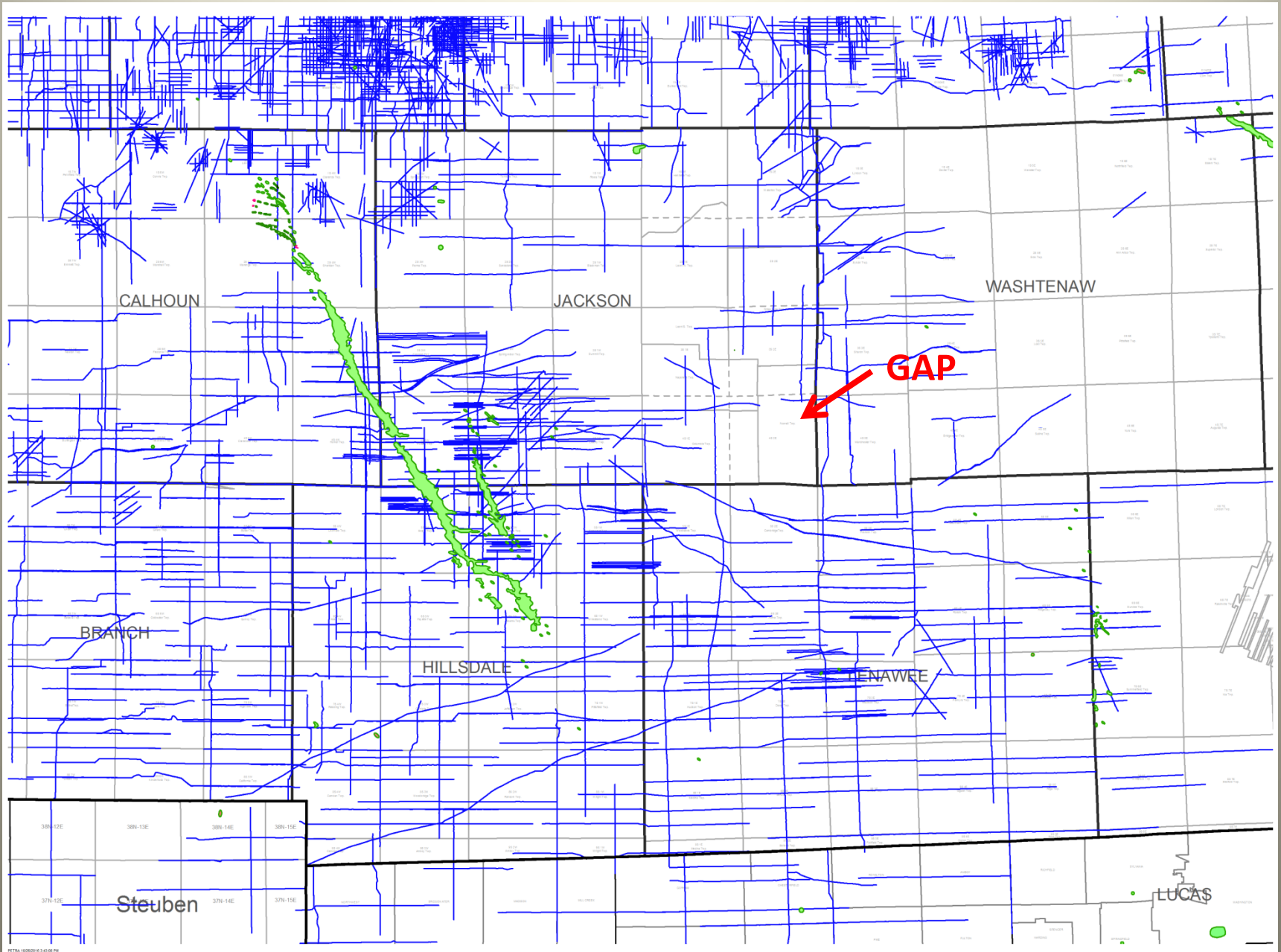
Cum. 3,033,477 BO



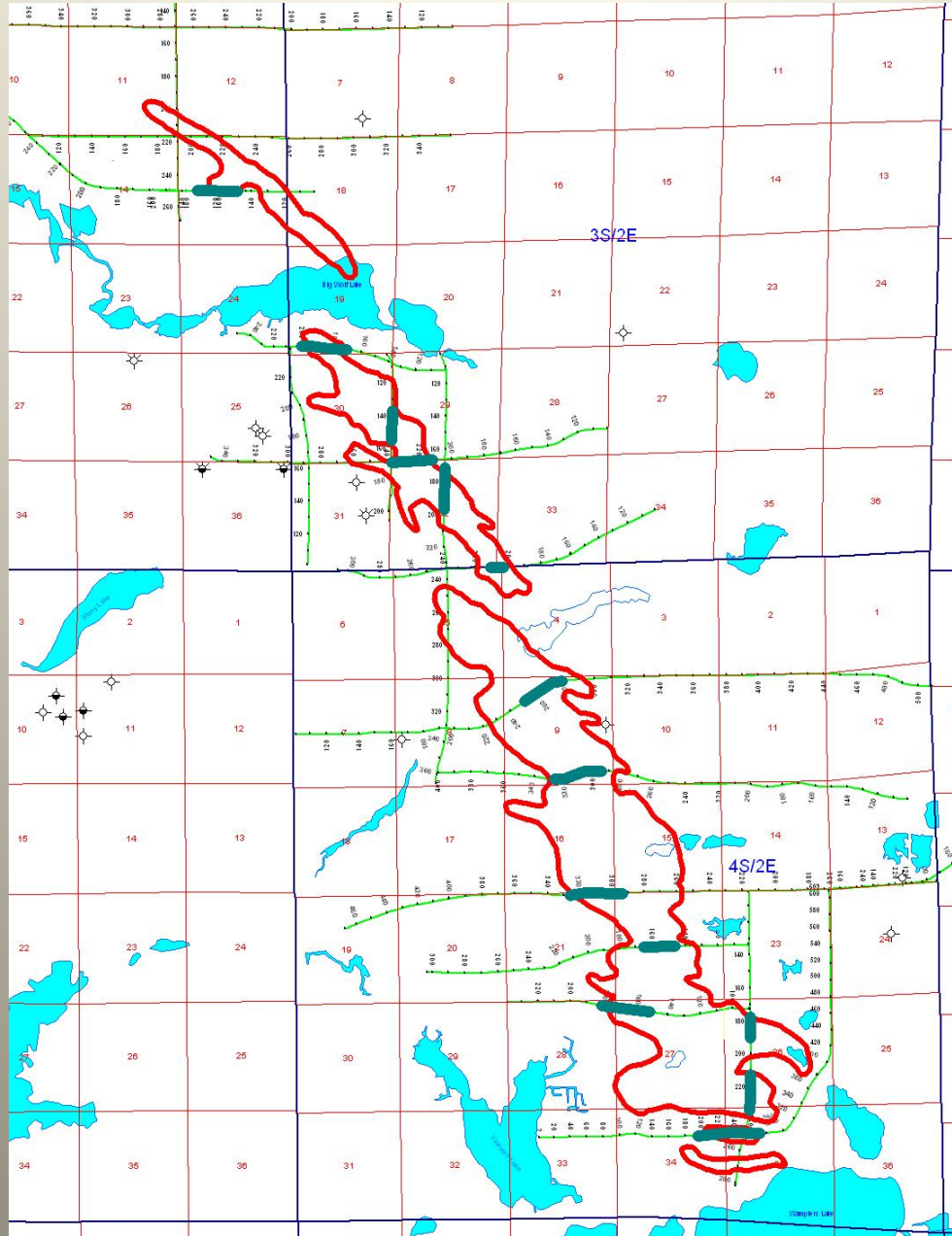
NAPOLEON DISCOVERY 2008

West Bay Exploration Co.

SEI 2-D seismic



Explore with 2D Seismic

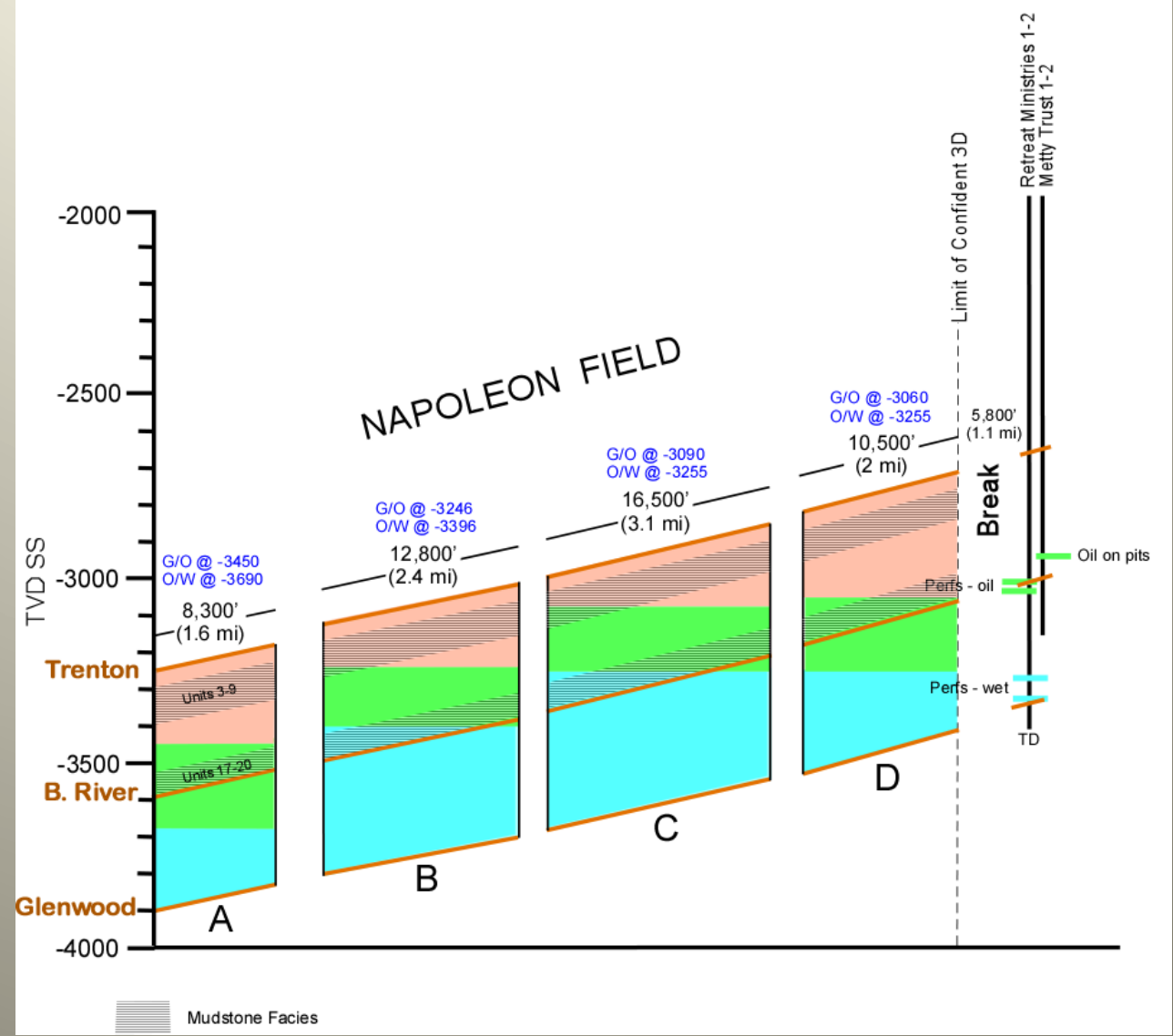
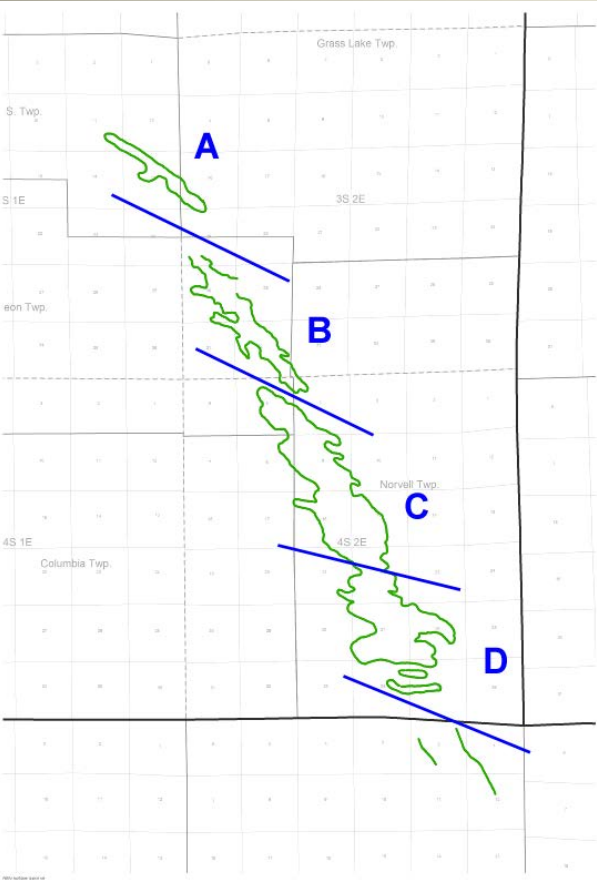


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Facies distribution relative to G/O & O/W contacts

NORTH

SOUTH



Total 57 wells
53 producers, 4 dry
93% success rate

28 Horizontals, 29 Vertical

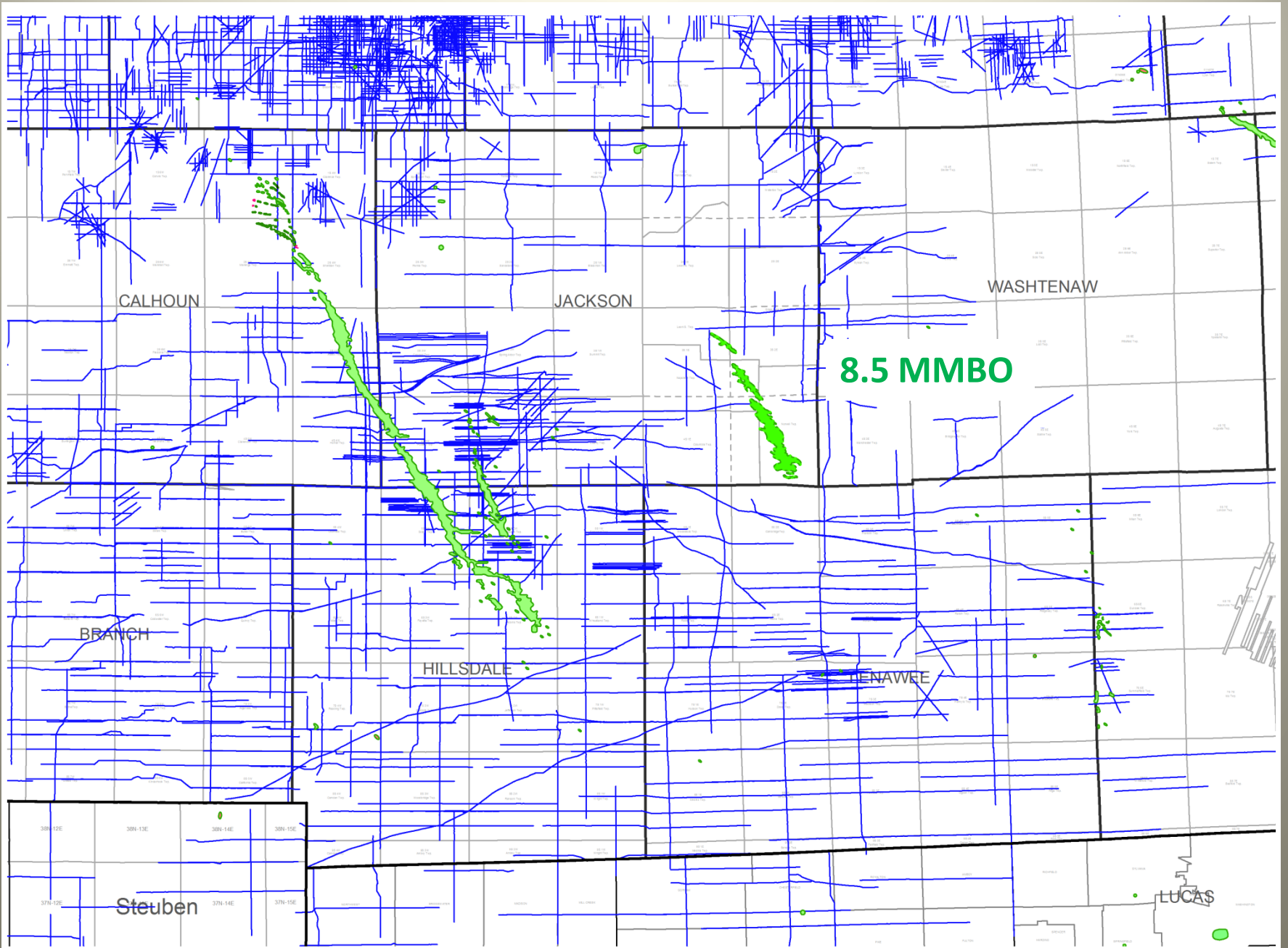
Cumulative Production

8,476,602 BO

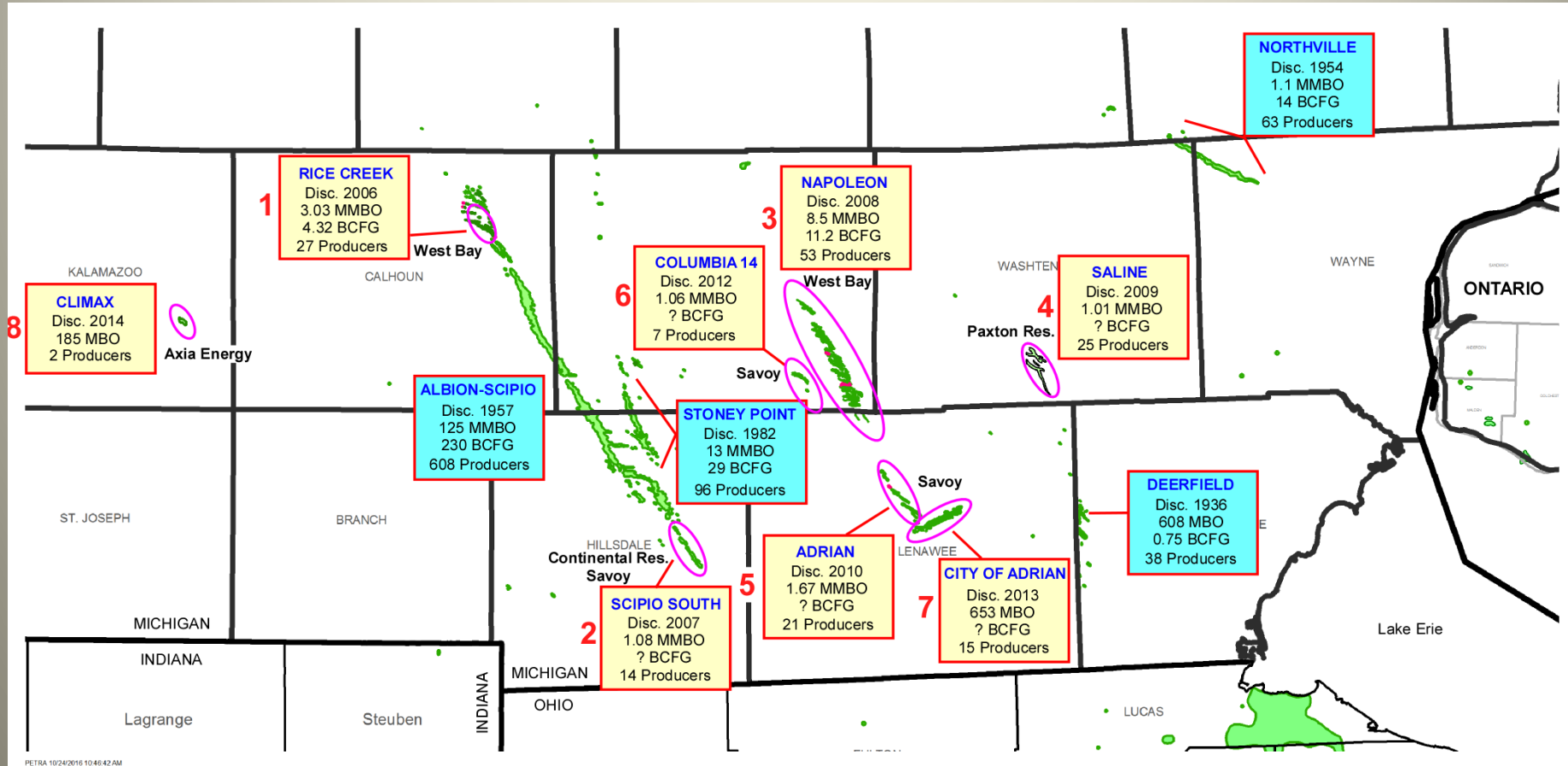
11,224,259 MCFG

7,306,582 BW

SEI 2-D seismic

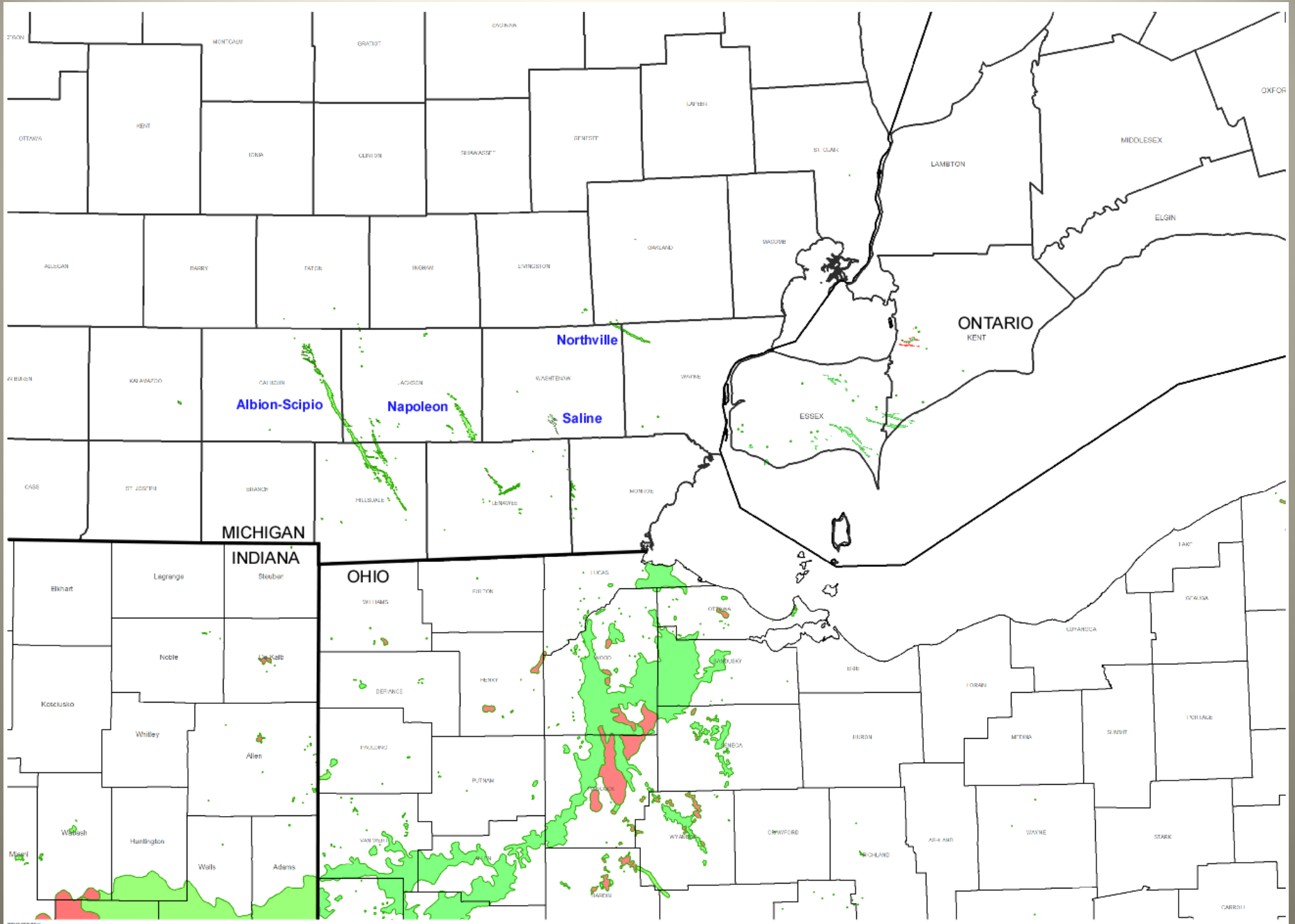


TRENTON-BLACK RIVER RECENT DISCOVERIES



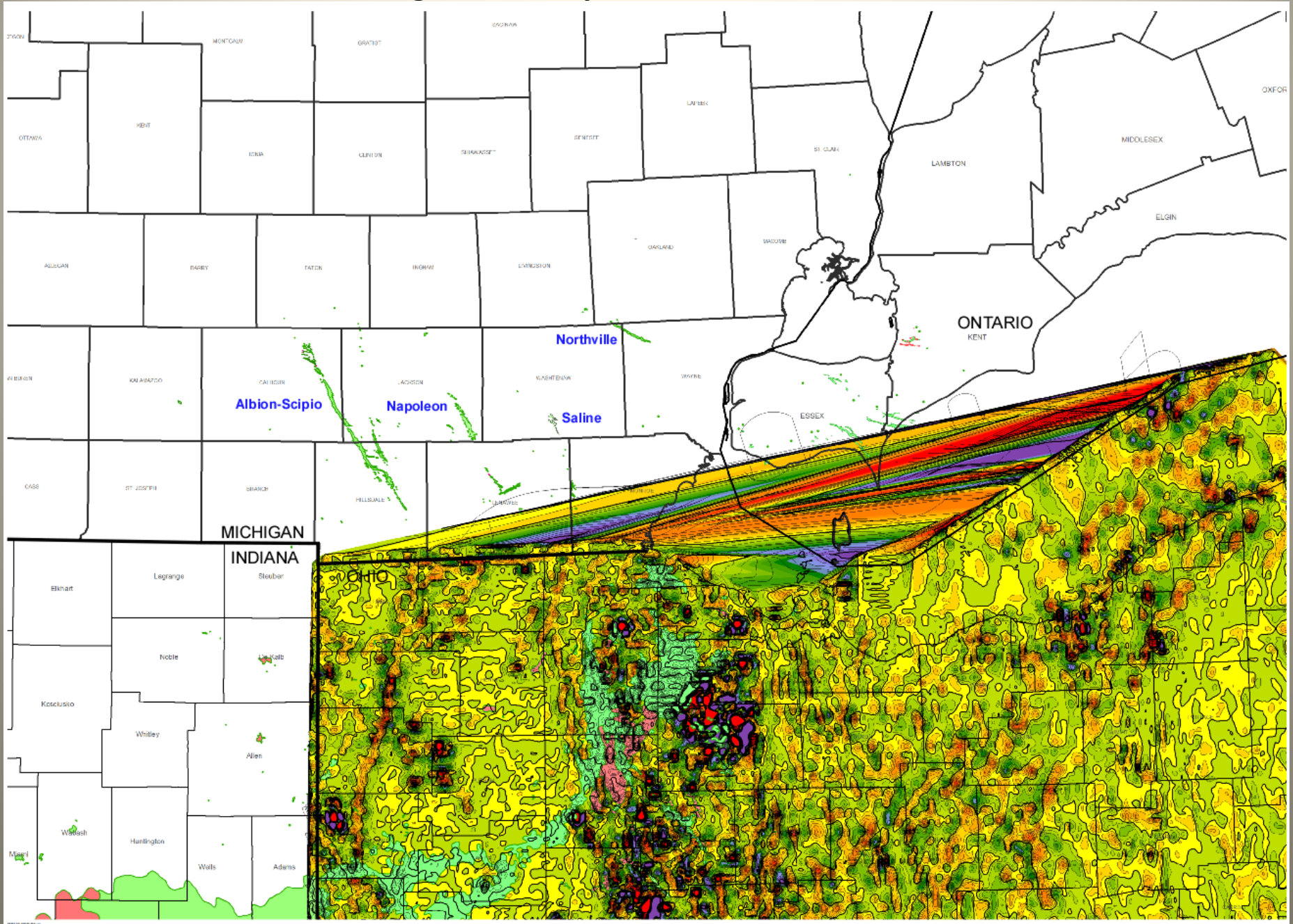
Historic Production = 140 MMBO

Recent Production = 17 MMBO (2D/3D Seismic)



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Magnetic Survey – Second Vertical Derivative



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Devonian Fault Re-activation Scenario

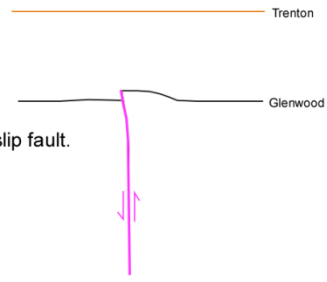
Taconic Orogenic Event

Acadian Orogenic Event

Trenton/B. River Devonian Re-activation Scenario

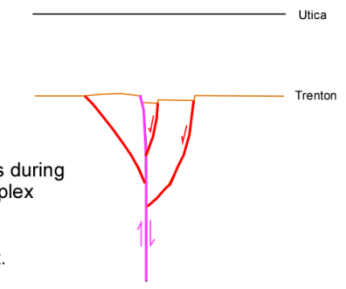
Trenton Time

Compression along oblique-slip fault.
Thin Trenton-BR section.



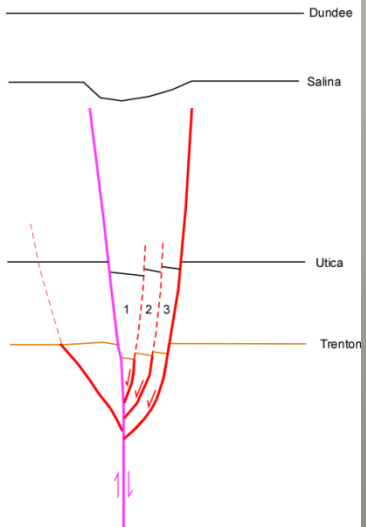
Utica Time

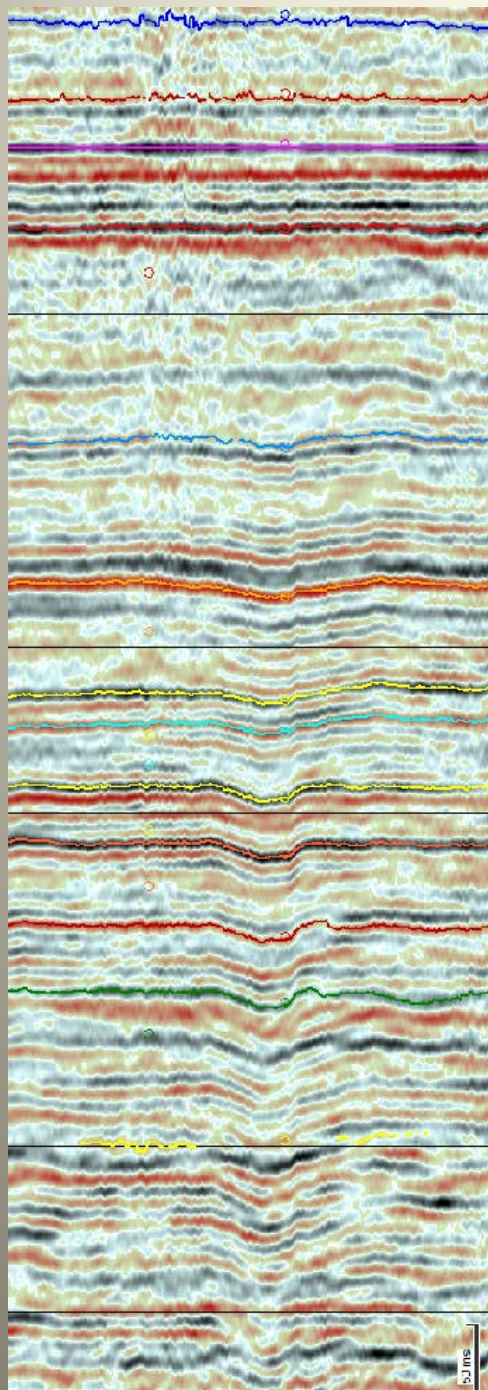
Normal faulting commences during formation of extensional duplex (fault splays).
Sagging on Trenton evident.
Utica thickens.



Dundee Time

Reactivation of extensional duplex.
Faulting up into Salina.
Pronounced sagging on Trenton.
Thickened Devonian section.





Traverse



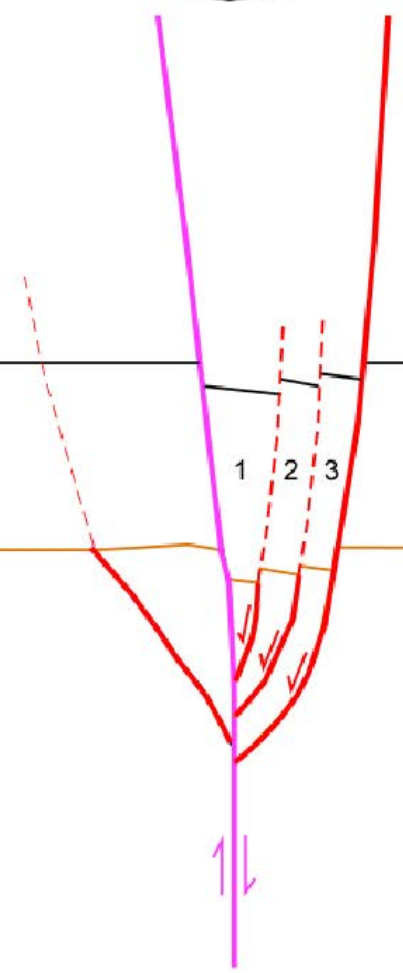
Salina



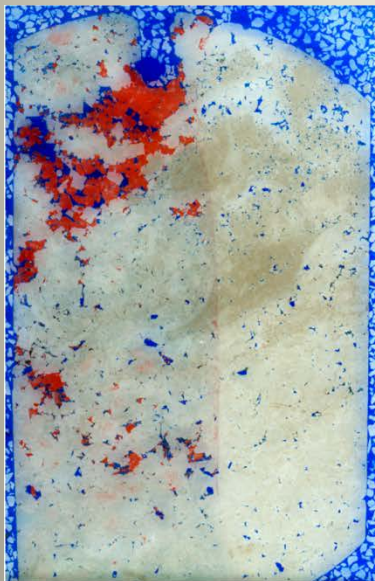
Utica



Trenton



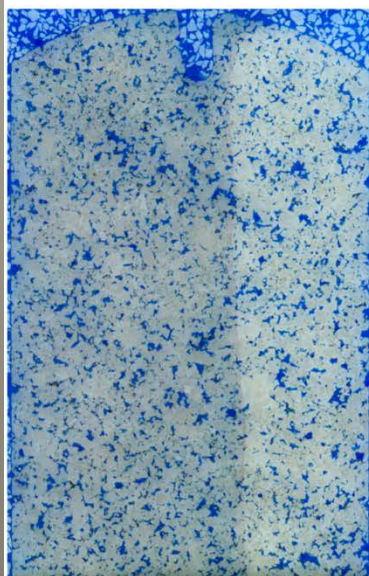
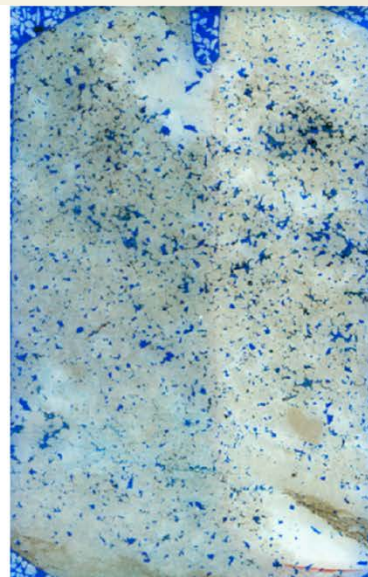
WBE 1-22 thin sections



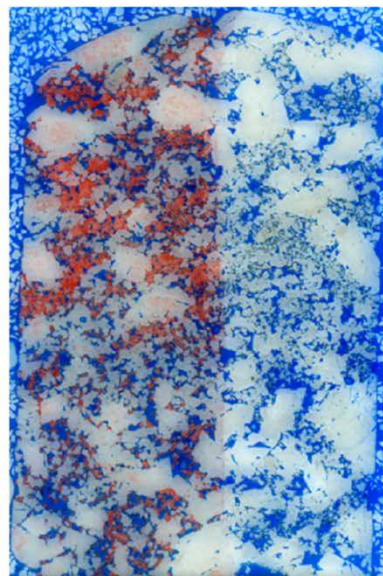
4070.3
3.6%, 0 mD



4063.6
7.4%, 14.4 mD

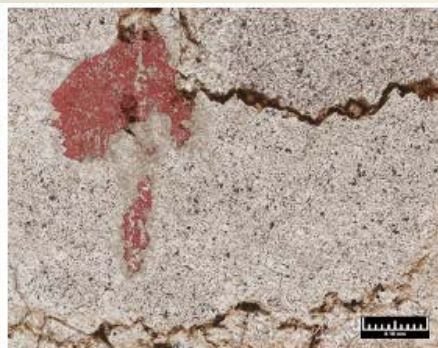
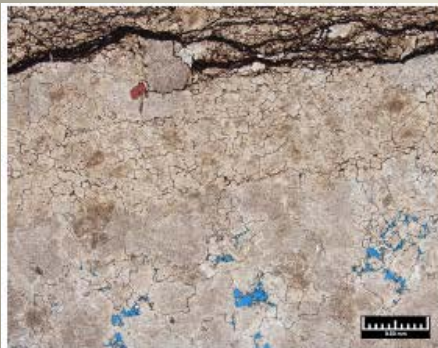


4089.1
13.0%, 311 mD

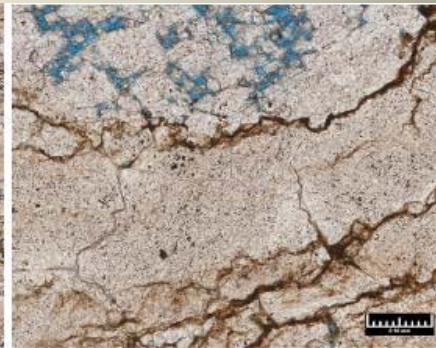
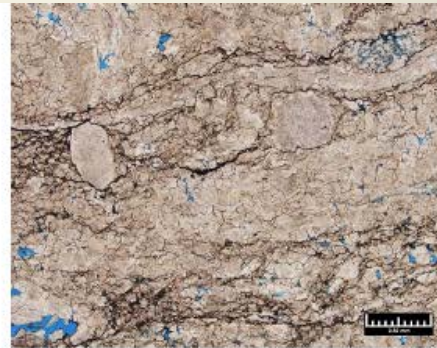


4082.95
19.8%, 14,000 mD

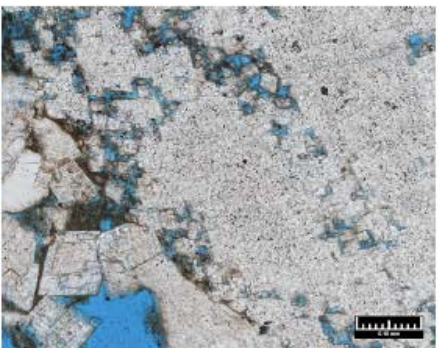
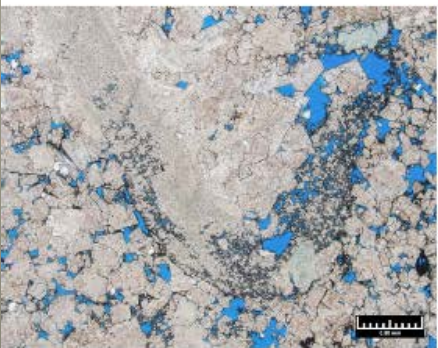
HCMA 1-27 thin sections



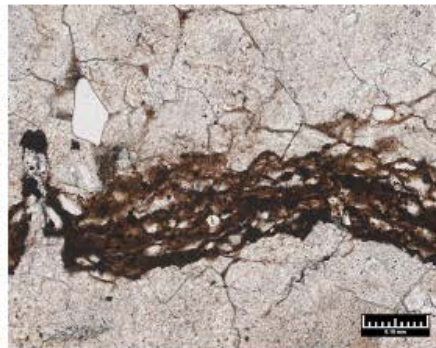
6058.5
1.0%, .0033 mD



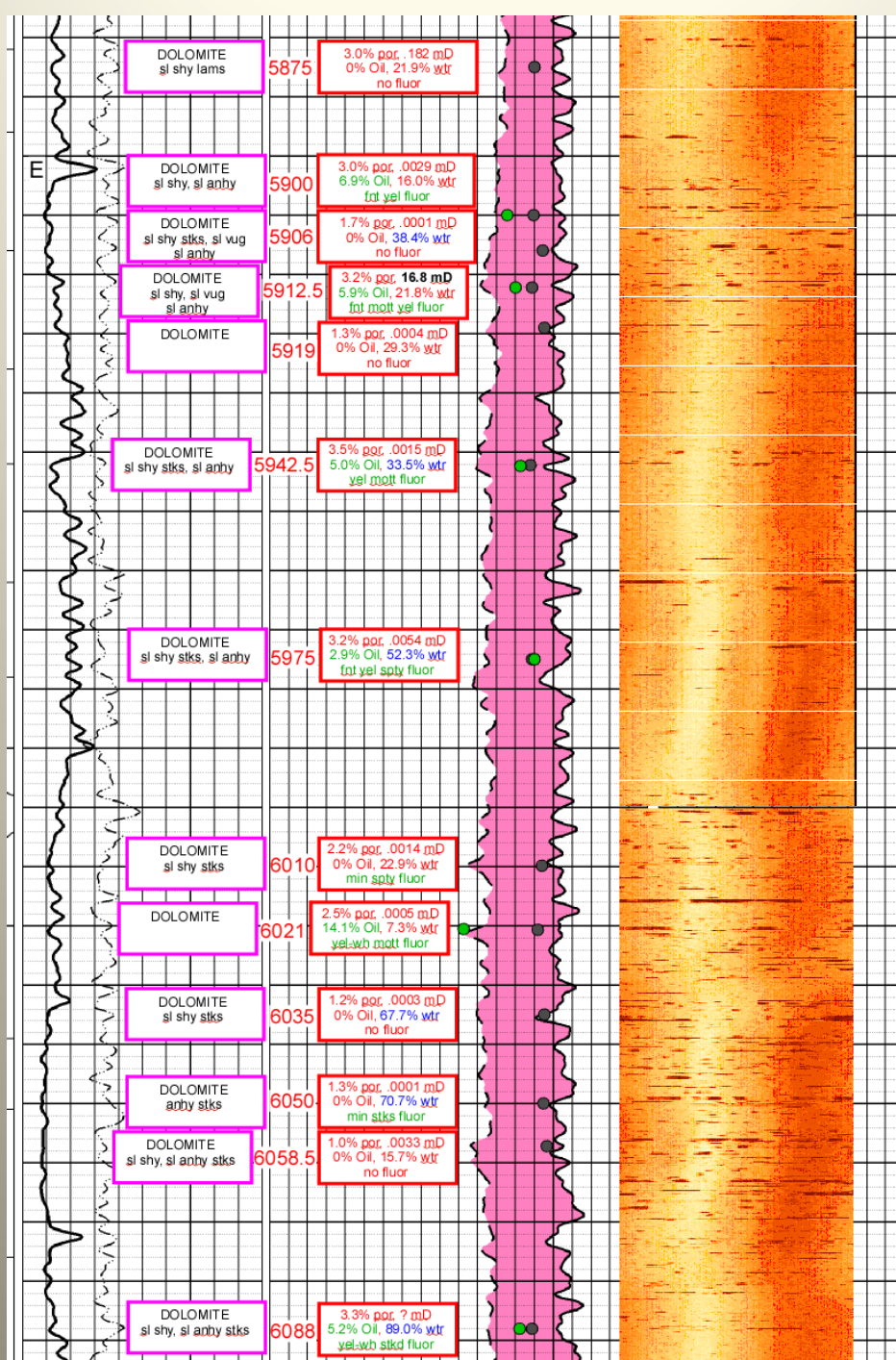
6010
2.2%, .0014 mD



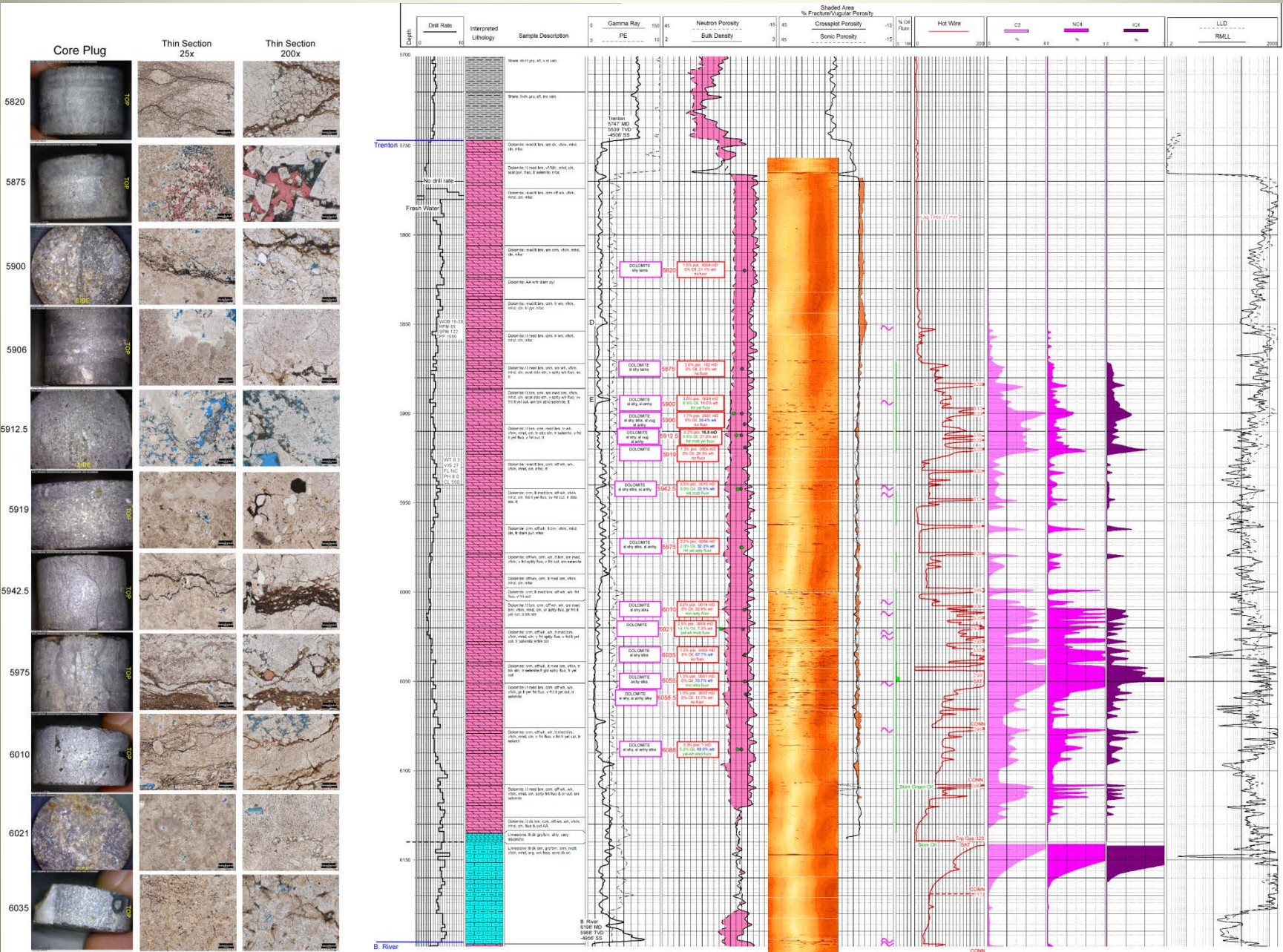
5912.5
3.2%, 16.8 mD



5942.5
3.5%, .0015 mD



HCMA 1-27



Average porosity/permeability in Trenton (core data)

HCMA 1-27 (OAKLAND CO.)

2.3%, 1.3 mD

WBE 1-22 (NAPOLEON FIELD)

6.9%, 901 mD

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CONCLUSION

- Trenton-Black River discovered in 1936 (Deerfield).
- Albion-Scipio discovered in 1957. It continues to be the largest oilfield in Michigan with cumulative production of 125 MMBO.
- Stoney Point (1985) was the last significant discovery until Rice Creek (2006).
- Rice Creek kicked off a resurgence in Trenton-Black River exploration utilizing both 2D & 3D seismic. Since Rice Creek, seven additional fields have been found cumulating 17 MMBO to date.
- Numerous tight reservoirs have hindered exploration in some areas. This is attributed to occlusion of existing porosity by HTD initiated by Devonian fault re-activation. **TIMING OF FAULTING CAN BE CRUCIAL!**
- Many areas unexplored due to high population density (e.g. Metro Detroit)