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Using the Matt Rine Pinnacle Reef Model to better understand the Petrolia East Oil Reef

Ian Colquhoun and Matt Rine, June 4, 2026

Prepared for the Ontario Oil, Gas, & Salt Resources Corporation
Permission to use material from ALPX Energy Canada ULC

Understanding Silurian pinnacle reefs in the Michigan Basin has long been both a scientific challenge and an operational necessity. These reservoirs are inherently complex, with significant heterogeneity in facies distribution, diagenesis, and fluid flow behavior that can materially impact exploration, development, and storage performance.

My work began with a simple objective: to better understand how these reefs were constructed and how their internal architecture controls reservoir behavior. Through detailed core analysis at the Michigan Geological Repository for Research and Education (MGRRE), integrated with wireline logs, regional stratigraphy, and later seismic data, I developed a revised facies architecture and sequence stratigraphic framework for Niagaran reef complexes. This work helped bridge the gap between data-rich and data-constrained reefs, providing a more predictive model that has since been applied across the basin.

A key outcome of this research was demonstrating that reef growth, reservoir quality, and fluid distribution are fundamentally tied to depositional processes and subsequent diagenetic overprinting—rather than being purely stochastic. By integrating multiple datasets into cohesive geologic models, we can better predict reservoir performance, optimize well placement, and evaluate opportunities for gas storage, CO_2 sequestration, and hydrocarbon recovery.

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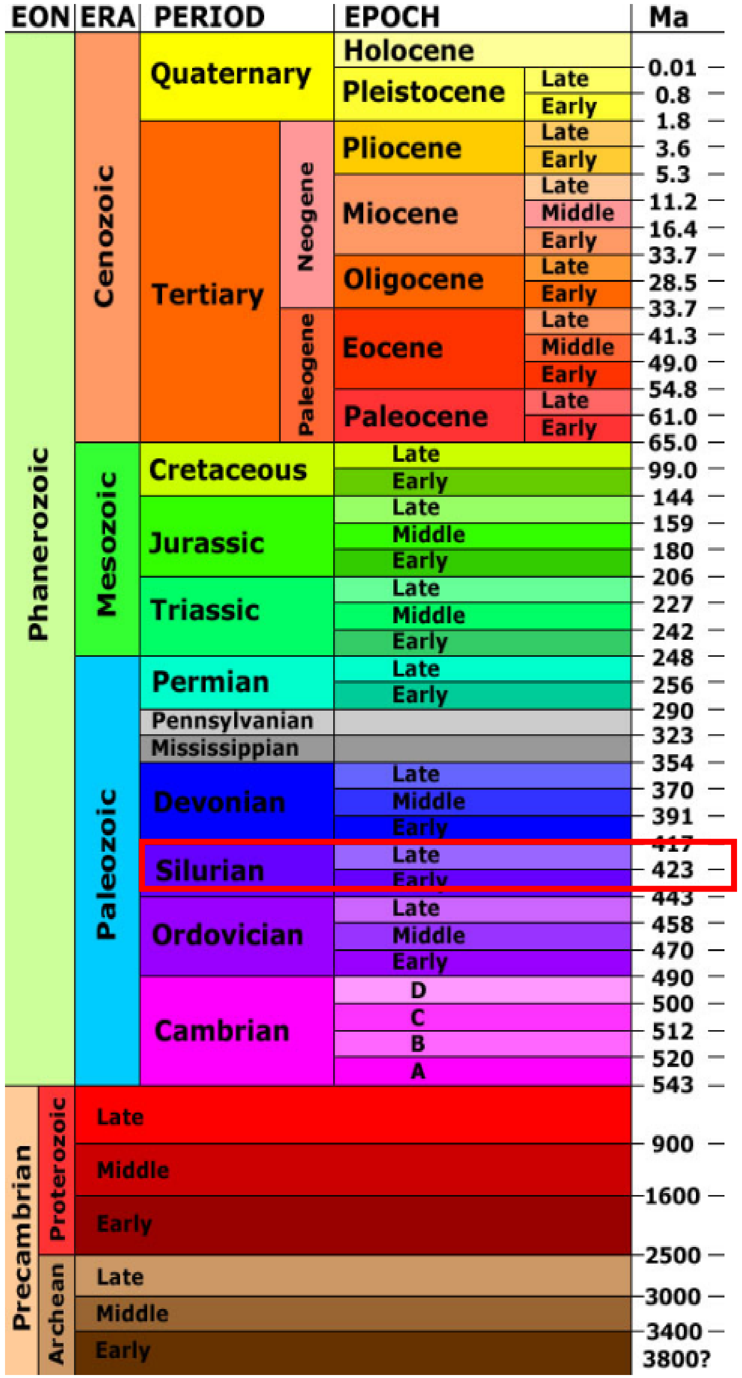
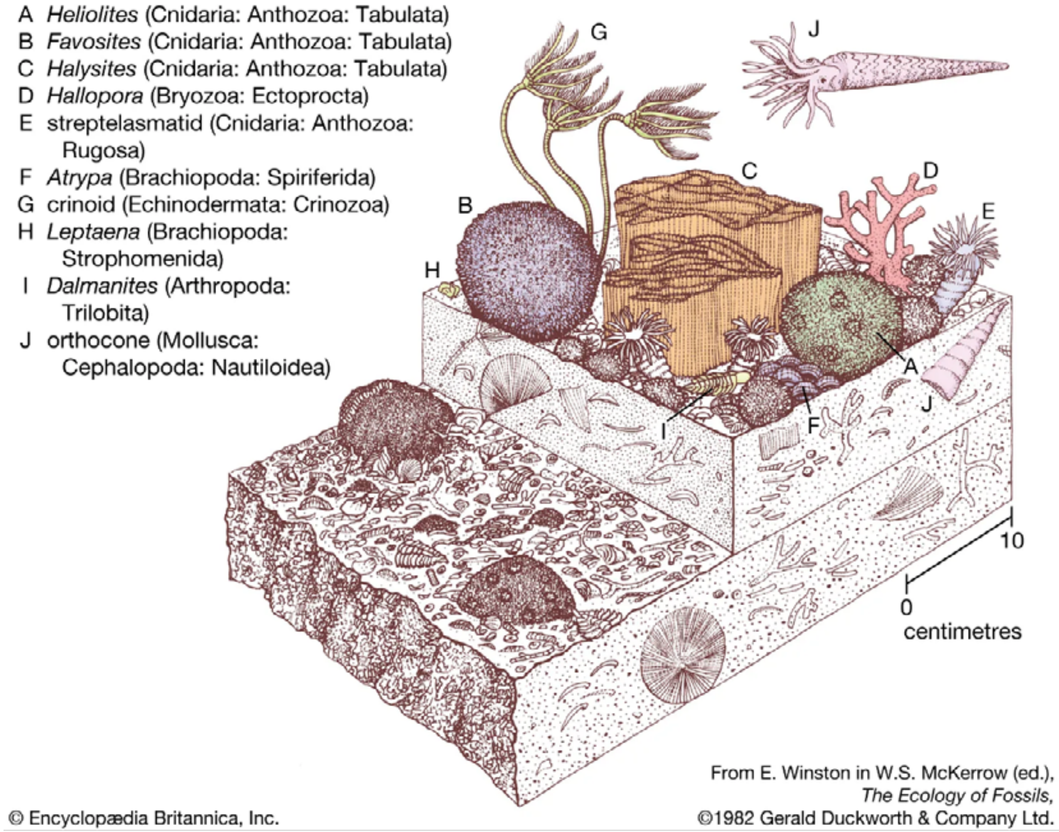
Geologic Time Scale



Silurian period began 443.8 mya and ended 419.2 mya, The Silurian period in North America was marked by significant marine transgression events, particularly during the Middle Silurian. This period saw the formation of the Tippecanoe shallow sea, which was characterized by the deposition of marine carbonates, evaporates and shales.



http://3dparks.wr.usgs.gov/coloradoplateau/images/timescale.jpg

Importance of Red and Green Algae during the formation of reefs:

Red and green algae play a crucial role in the formation and maintenance of coral reefs. Red algae are essential for stabilizing reef structures and providing a foundation for coral growth. Green algae are commonly found in tidal flats and in shallow patch reefs contributing to the health and stability of the reef ecosystem. Their presence filters pollutants from the water and supports a diverse range of marine life (Arizona State University).

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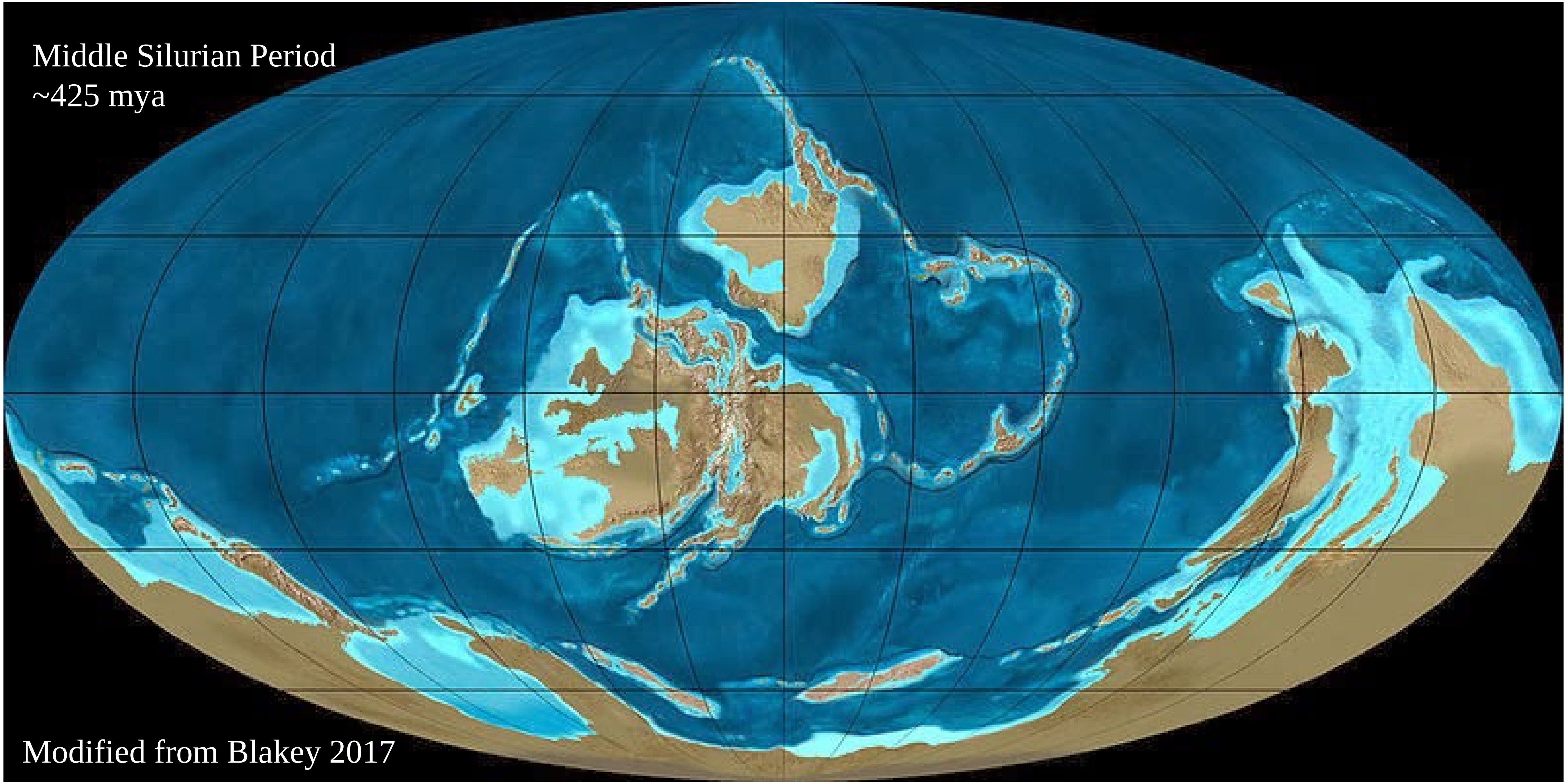
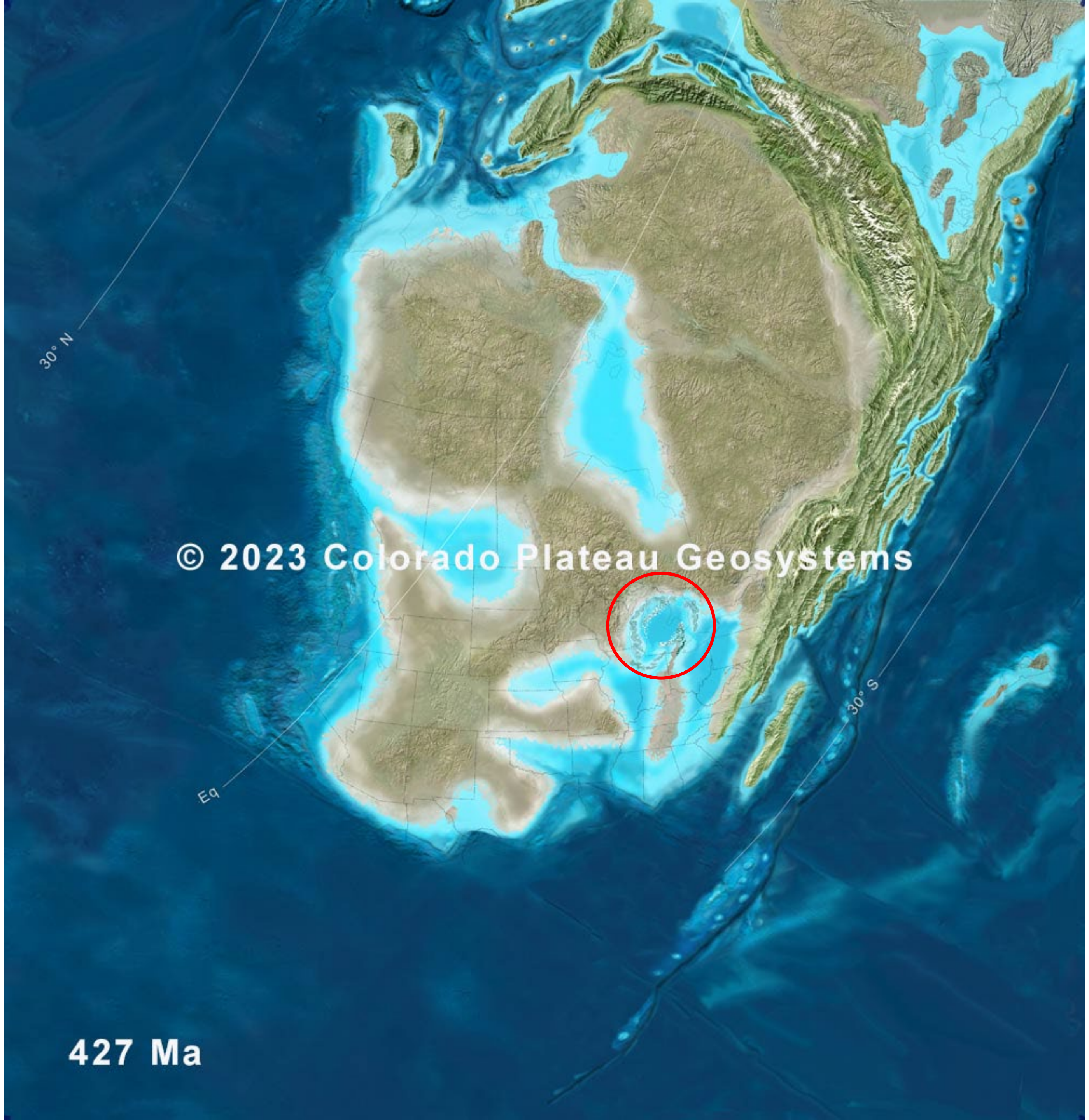
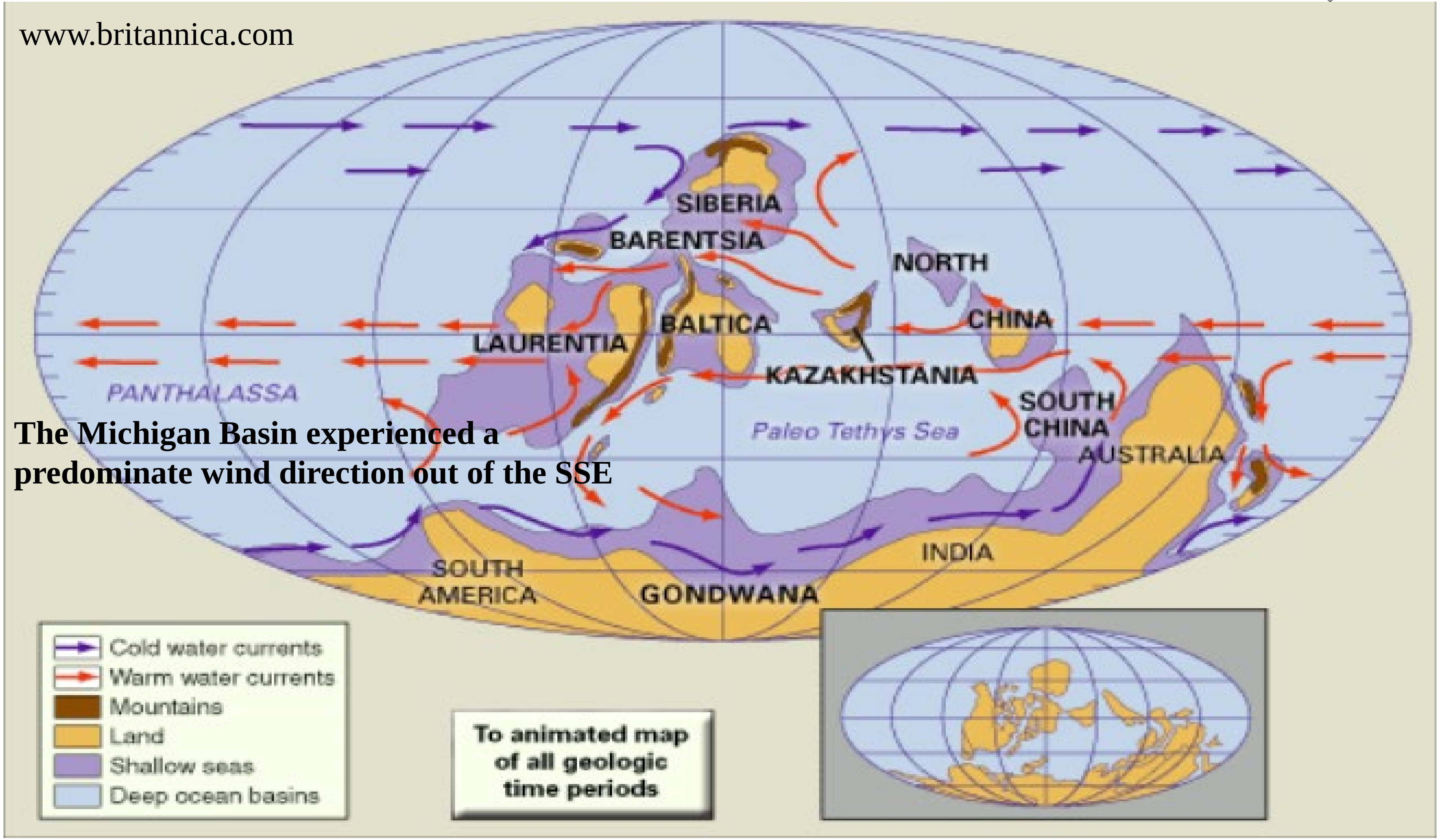




Paleogeography of North America during Middle Silurian time showing the land mass and inland seas that deposited sediments into the Appalachian and Michigan Basins, more specifically the development of pinnacle reefs along the basin margins.



www.britannica.com

The Michigan Basin experienced a predominate wind direction out of the SSE

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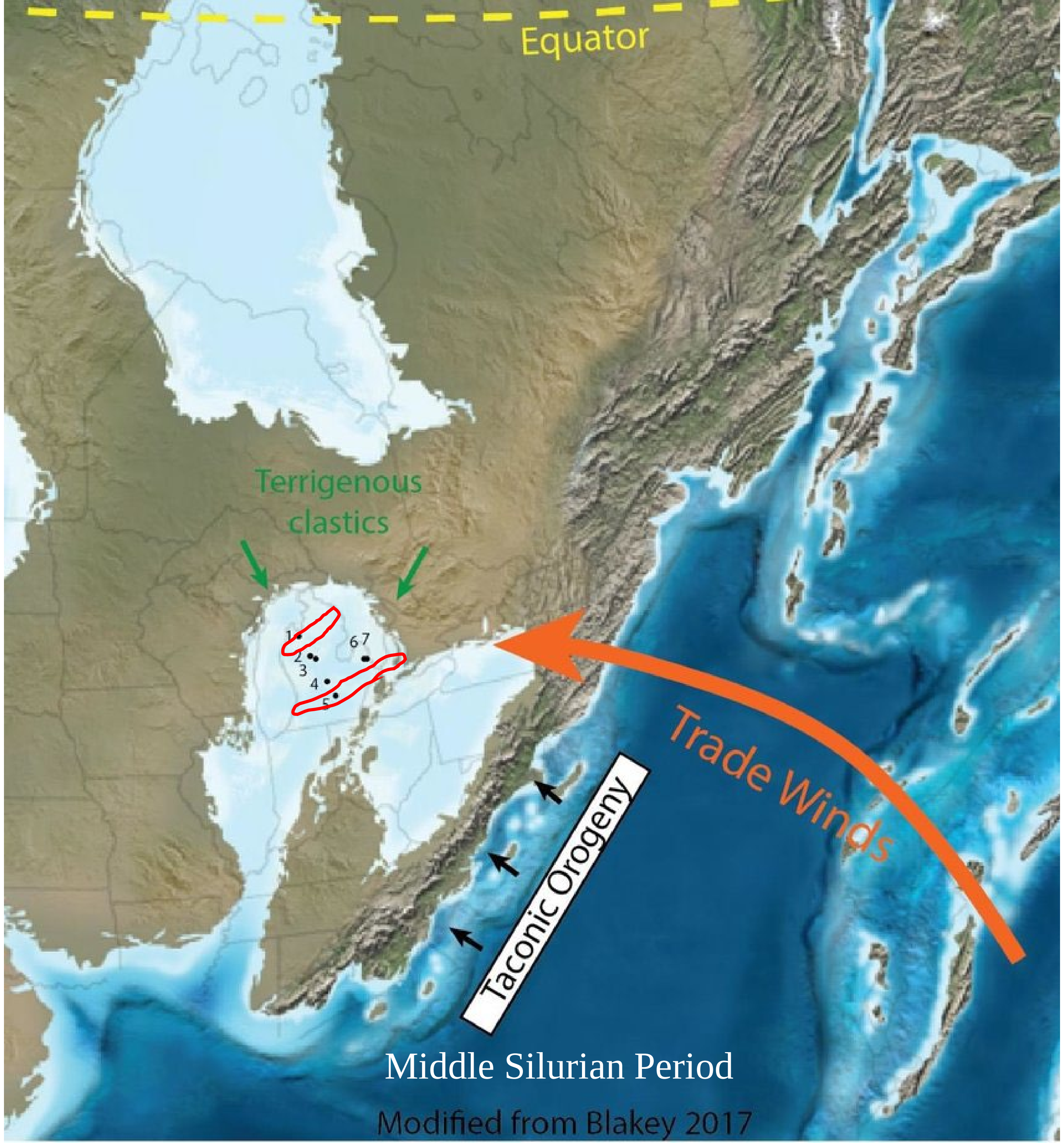
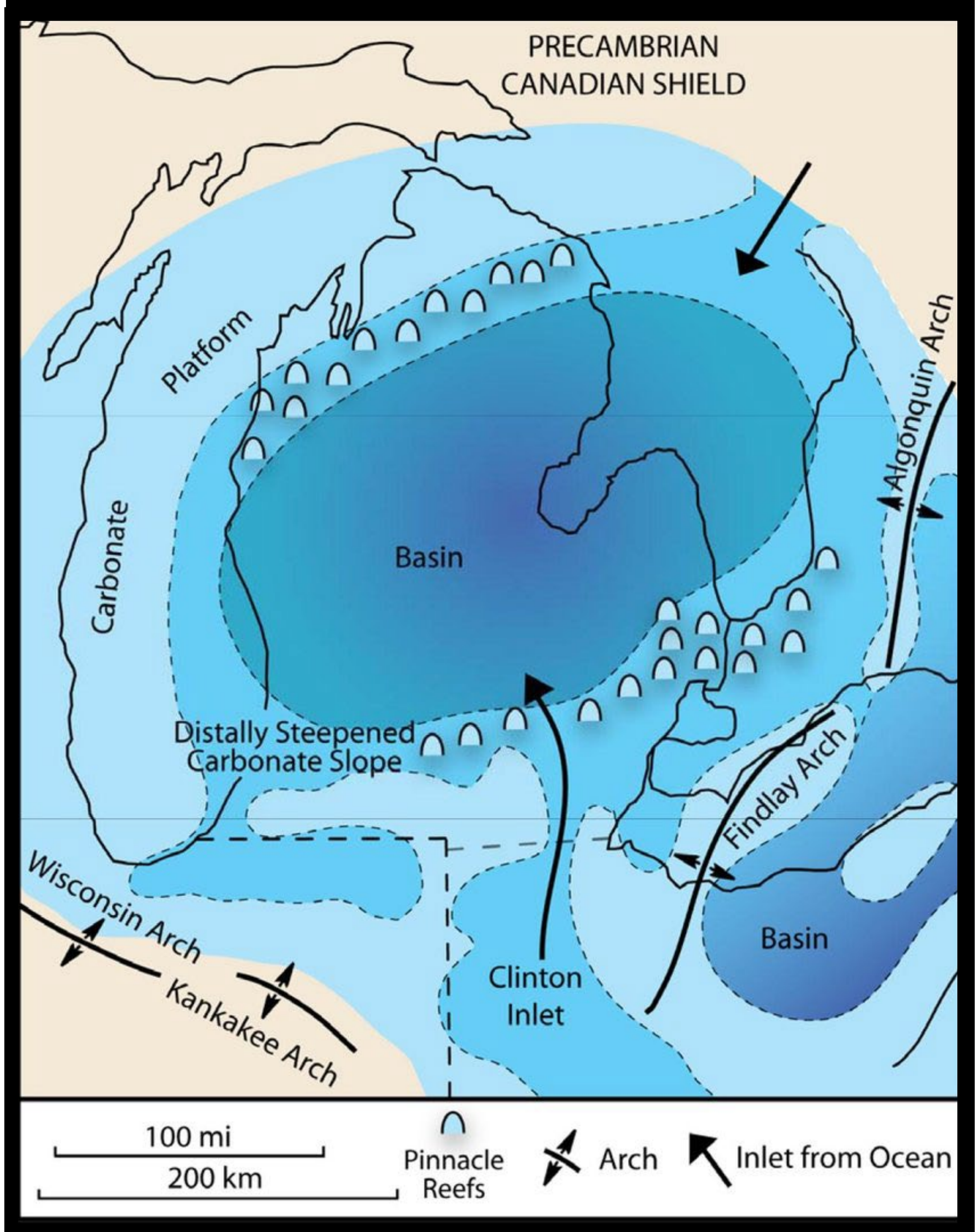
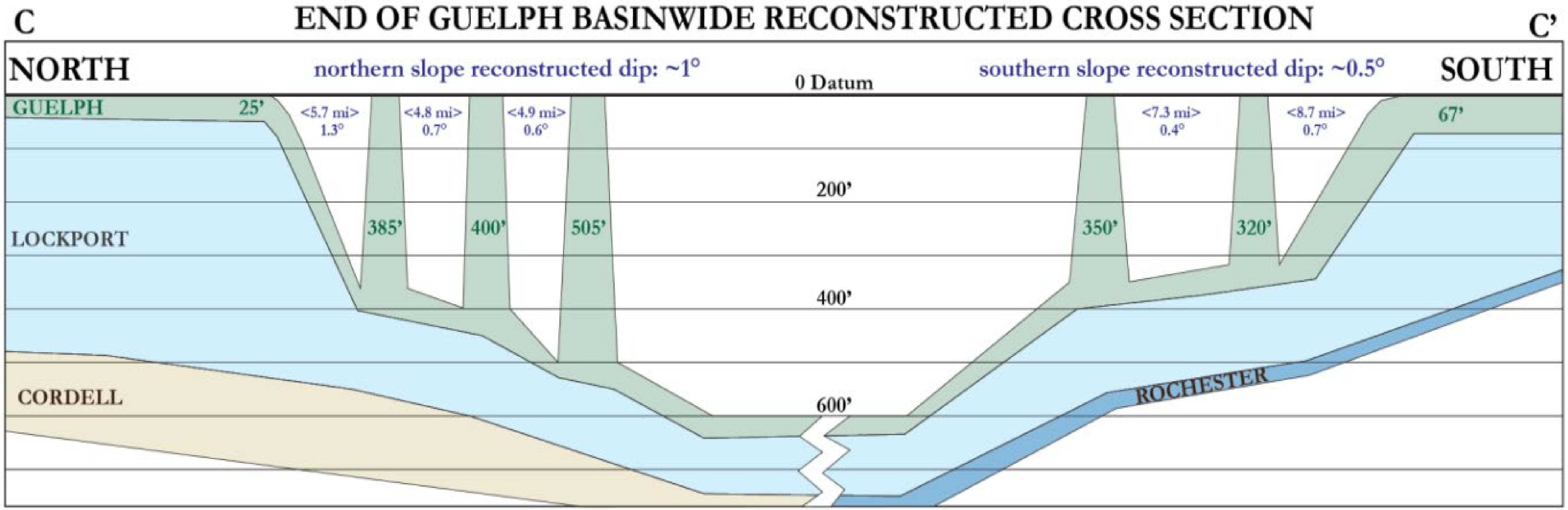


Trade winds come across the Appalachian mountains in response to the Coriolis effect are influenced by local and regional topography

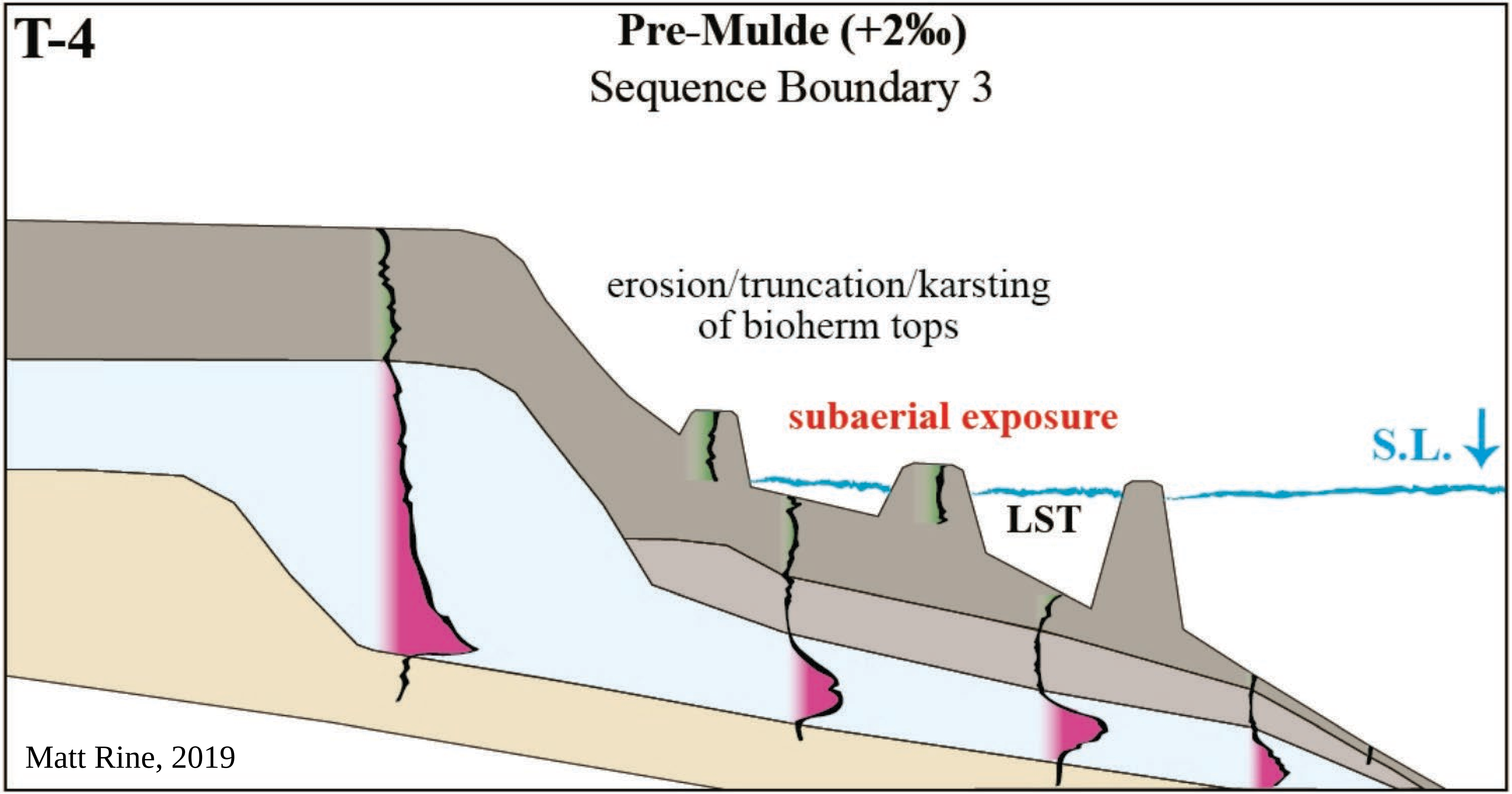


The predominate wind direction was rotated along with the North American continent from an SSE direction to an ENE-WSW orientation. Note that the pinnacle reefs in the northern and southern trends are aligned along an ENE-WSW direction present day, in alignment with the predominate wind direction that existed during the Middle Silurian.

D. Prezbindowski et al, 2017, AAPG Datapages Article 51343; Silurian Reef Systems in the Illinois and Michigan Basins



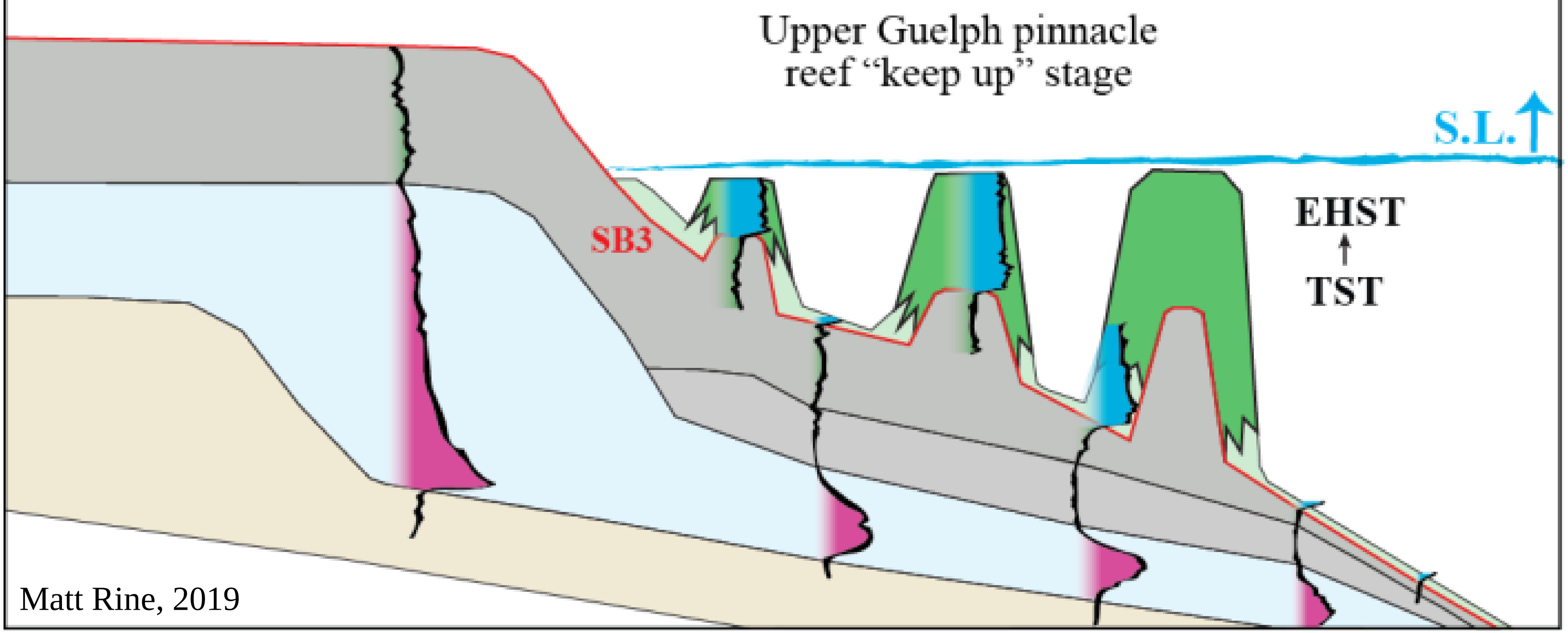
Matt Rine, 2019


T-4
Pre-Mulde (+2‰)
Sequence Boundary 3
erosion/truncation/karsting
of bioherm tops
subaerial exposure
S.L.
LST
Matt Rine, 2019

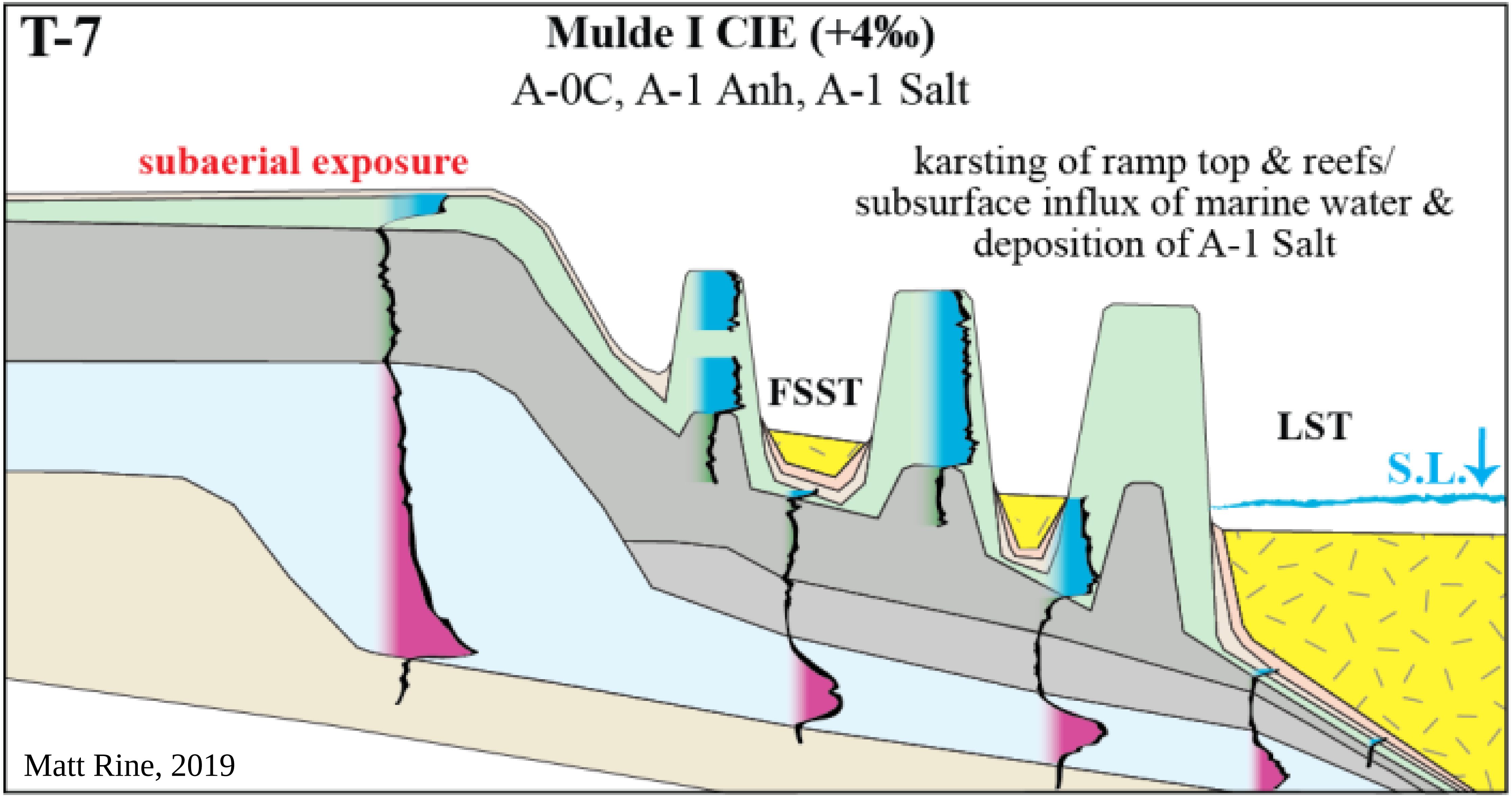
T-5

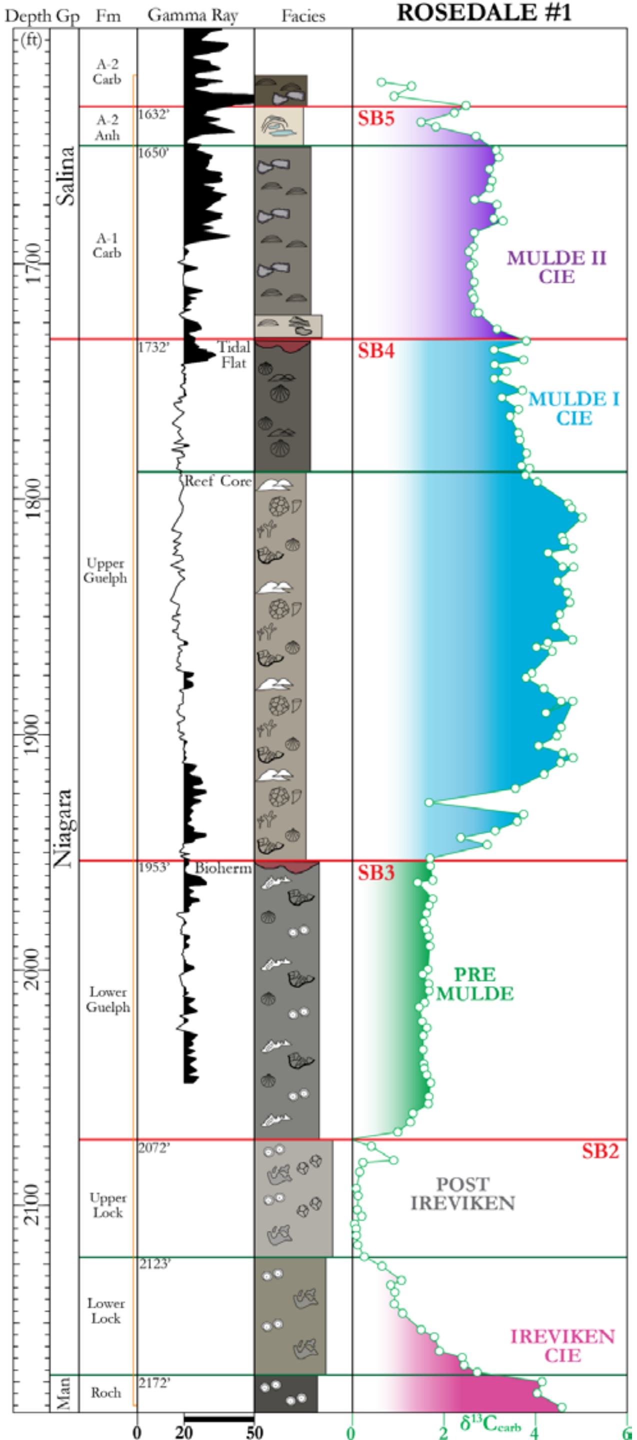
Mulde I CIE (+4‰)

Upper Guelph (Pinnacles)



Matt Rine, 2019


T-7
Mulde I CIE (+4‰)
A-0C, A-1 Anh, A-1 Salt
subaerial exposure
karsting of ramp top & reefs/
subsurface influx of marine water &
deposition of A-1 Salt
FSST
LST
S.L.
Matt Rine, 2019



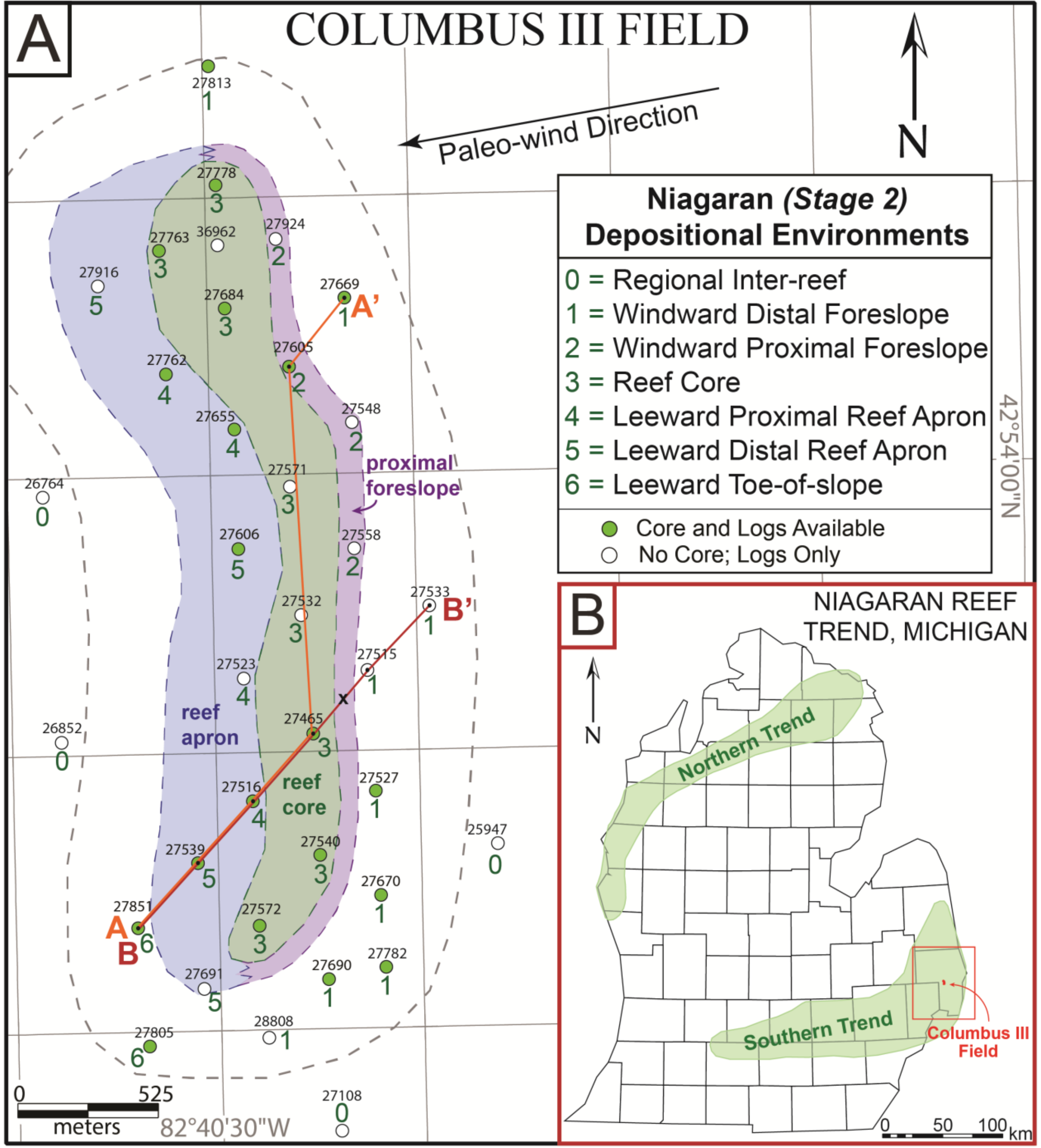
Upper Guelph (Upper Bioherm)

The depositional environments for the lower and upper Guelph was interpreted from core samples and are constrained by their carbon-13 isotopic excursions; these excursions help define the placement of major sequence boundaries (sea level changes)

Lower Guelph (Lower Bioherm)

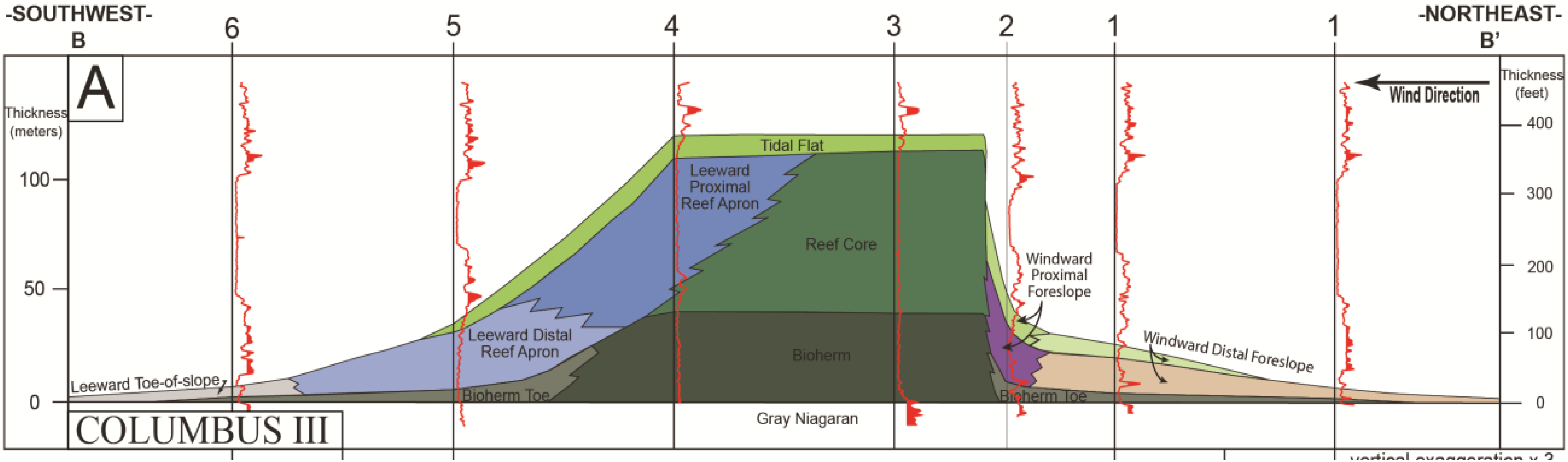
Lockport Group

Matt Rine, 2019



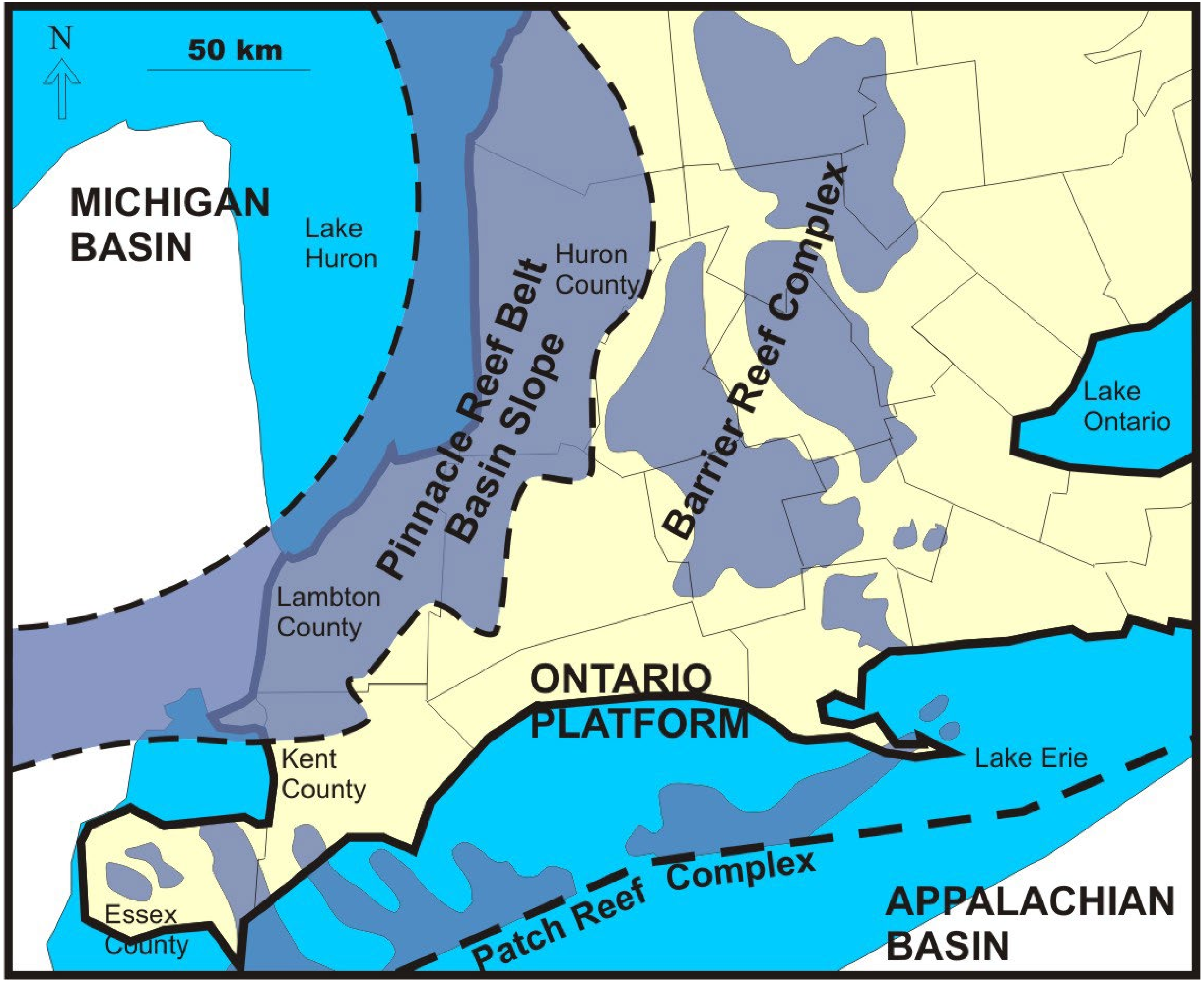
SW to NE transect through the Columbus III Field (B to B') to illustrate the depositional environments encountered for the Guelph across the pinnacle reef complex

Matt Rine, 2019



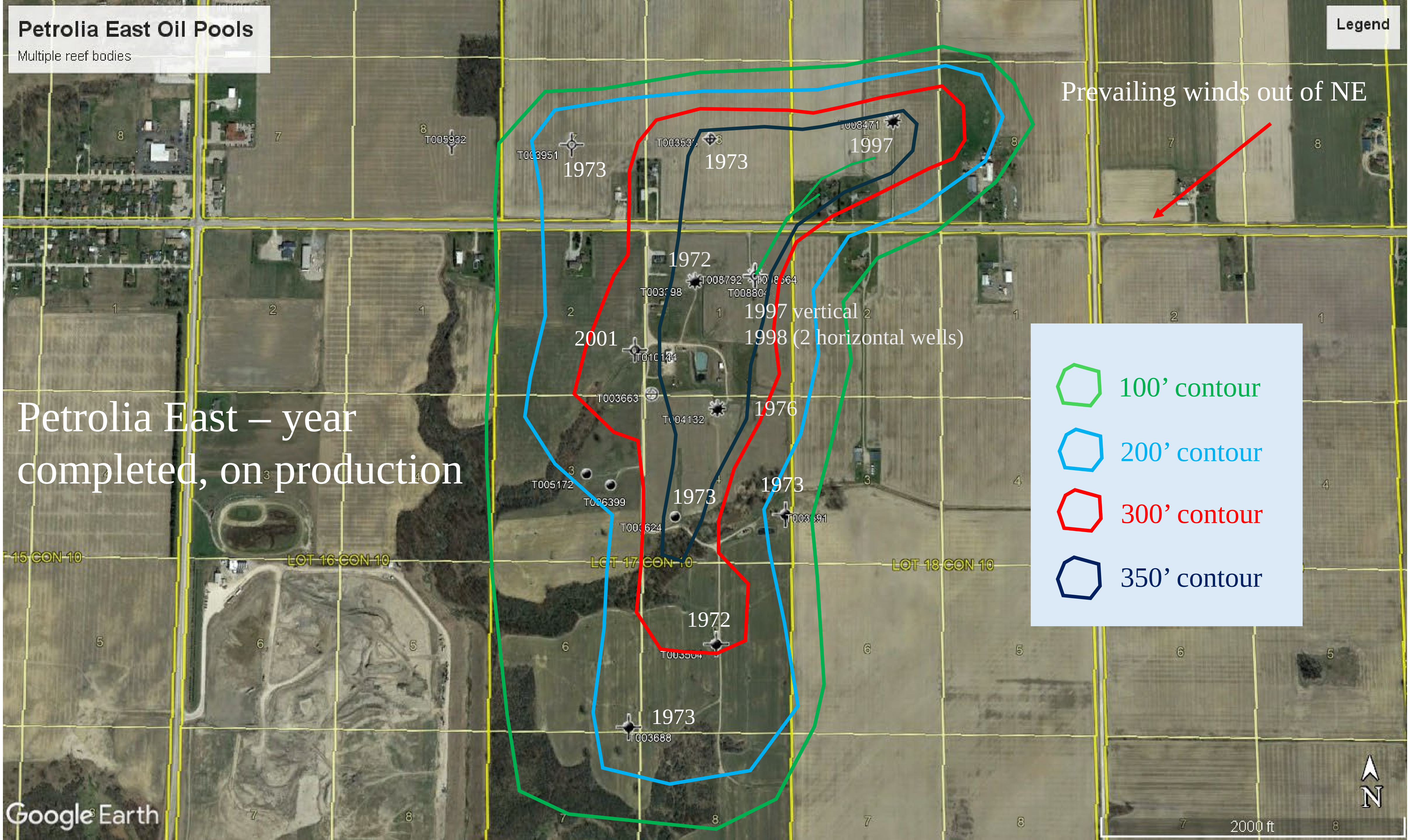
SW to NE vertically exaggerated (3:1) cross-section through Columbus III reef showing the major reef depositional environments along a six well transect; cross-section is flattened on the underlying Gray Niagaran or Lockport Group

Matt Rine, 2019



Reef belts in Ontario.
CSPG Reservoir issue 10
November 2016.
(Modified from Coniglio et al., 2003)

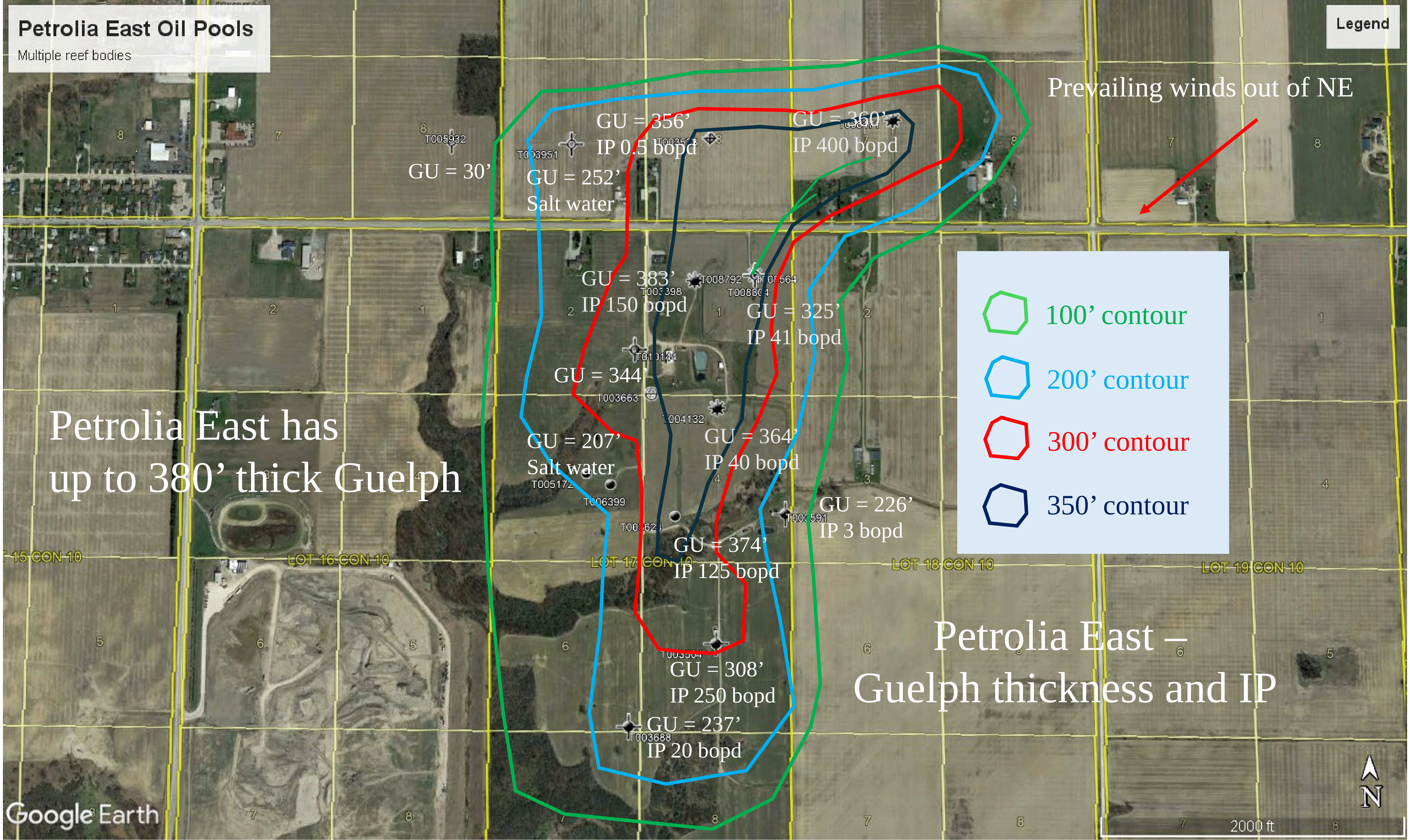

Oil and Gas Pools North Lambton Co.
Rochester structure and A-2 Salt Isopach contours
Production figures to end of 2023
Legend
Grand Bend
855,000 BO
Plympton 5-19-VI
250,000 BO
Warwick
770,000 BO
Wanstead
590,000 BO
Petrolia East
790,000 BO
Corey East – 905,600 BO
Port Franks
Mt Carmel
West McGillivray
Lucan
BOSANQUET
Kettle Point
Thedford
Sylvan
Parkhill
Ailsa Craig
Denfield
WILLIAMS
Nairn
Highland Glen
Forest
Arkona
Ilderton
Keyser
Camlachie
Uttoxeter
PLYMPTON
WARWICK
LOBO
Coldstream
Wrightmans Corners
Point Edward
Sarnia
SARNIA
Reeces Corners
Watford
Strathroy
Komoka
Wyoming
Kerwood
ADELAIDE
Mt Brydges
Marthaville
Petrolia
CARADOC
Napier
ENNISKILLEN
BROOKE
MOORE
Alvinston
Melbourne
Muncey
Google Earth
20 km
N



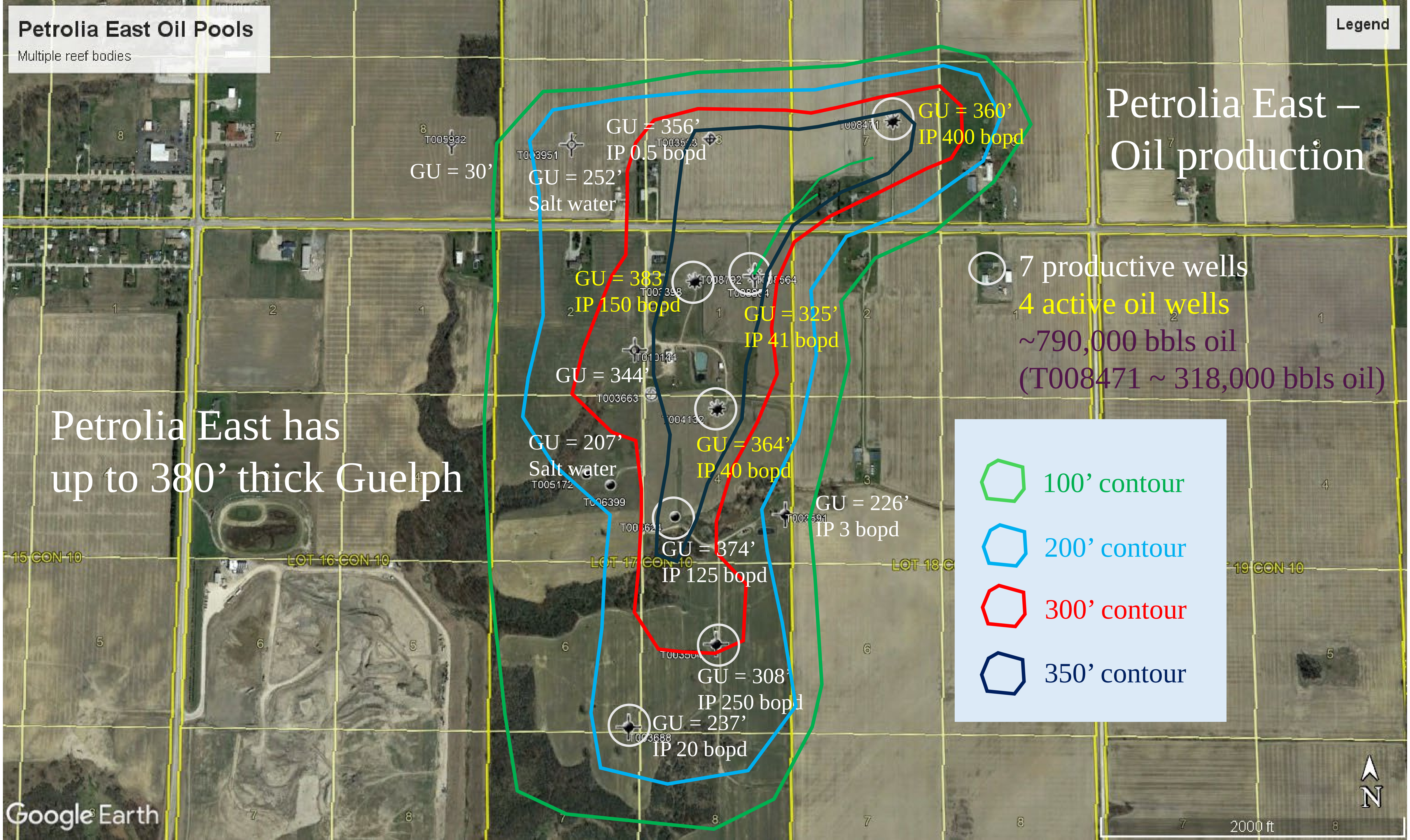
Petrolia East Oil Pools
Multiple reef bodies
Legend
Prevailing winds out of NE
Petrolia East – year completed, on production
1973
1973
1997
1972
1997 vertical
1998 (2 horizontal wells)
2001
1976
1973
1973
1972
1973
100’ contour
200’ contour
300’ contour
350’ contour
LOT 16 CON 10
LOT 17 CON 10
LOT 18 CON 10
N
2000 ft
Google Earth

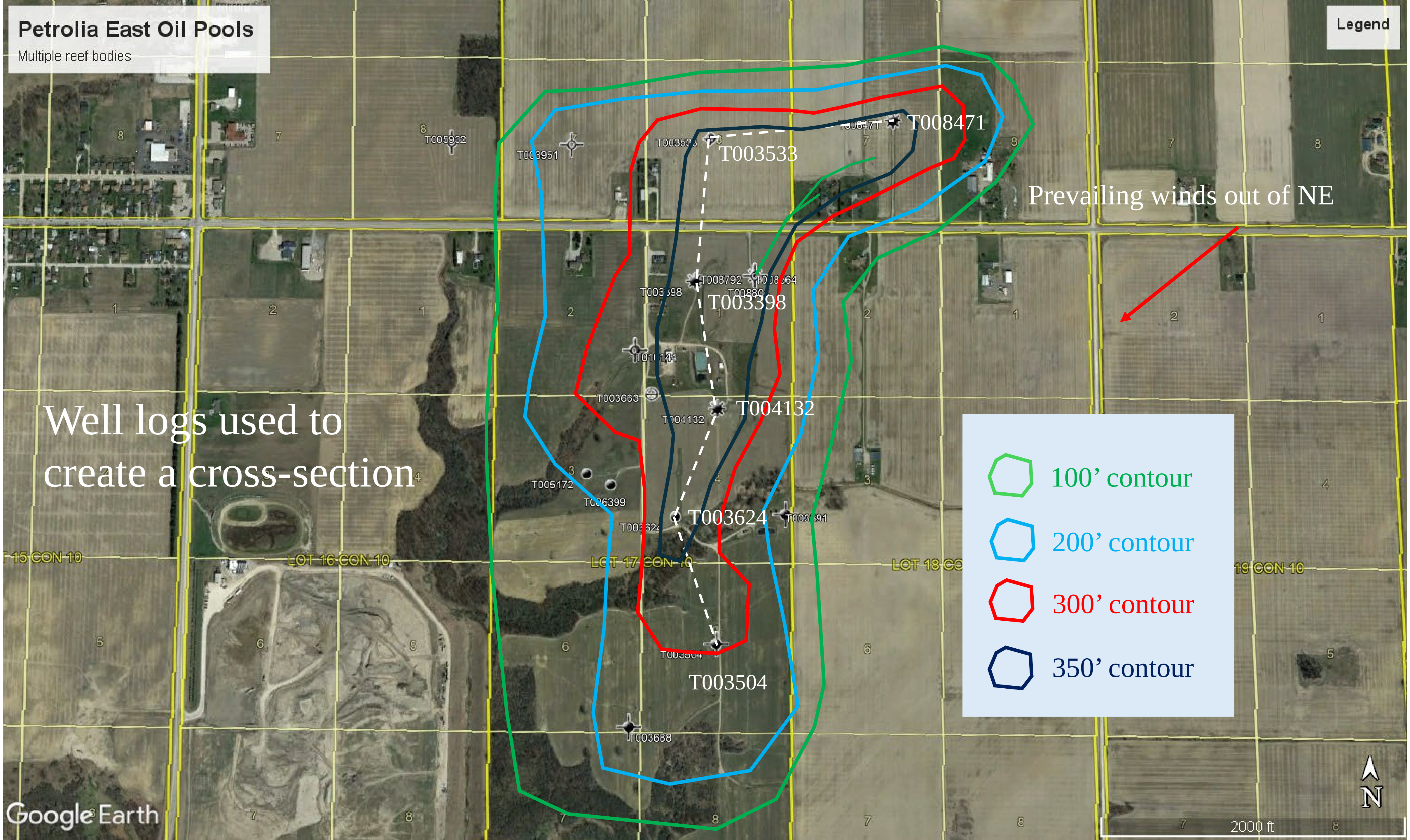
Well #	RF (ft)	GU	GU subsea	Goat Island	GI subsea	GU isopach	Pressure psig
T008471	684.5	1864	-1180	2228	-1543.5	364	750
T003533	673	1834	-1161	2190		356	
T003951	673	1938	-1265	2190		252	
T003398	671	1807	-1136	2190		383	843
T008804	683	1865	-1182	2190		325	681
T008564	683.5	1858	-1175	2190		332	
T010144	673	1834	-1161	2178	-1505	344	
T004132	679	1826	-1147	2190		364	901
T005172	670	1983	-1316	2190		207	
T003591	673	1964	-1291	2190		226	
T003624	671	1816	-1145	2190		374	
T003504	676	1882	-1206	2190		308	800
T003688	671	1953	-1282	2190		237	
T005932	673	2179	-1506	2208	-1535	29	

Tops highlighted in red are estimated


Petrolia East Oil Pools
Multiple reef bodies
Legend
Prevailing winds out of NE
GU = 30'
GU = 356'
IP 0.5 bopd
GU = 360'
IP 400 bopd
GU = 252'
Salt water
GU = 383'
IP 150 bopd
GU = 325'
IP 41 bopd
GU = 344'
GU = 207'
Salt water
GU = 364'
IP 40 bopd
GU = 226'
IP 3 bopd
GU = 374'
IP 125 bopd
GU = 308'
IP 250 bopd
GU = 237'
IP 20 bopd
100' contour
200' contour
300' contour
350' contour
Petrolia East has
up to 380' thick Guelph
Petrolia East –
Guelph thickness and IP
LOT 16 CON 10
LOT 17 CON 10
LOT 18 CON 10
LOT 19 CON 10
N
2000 ft
Google Earth

Petrolia East – Oil production

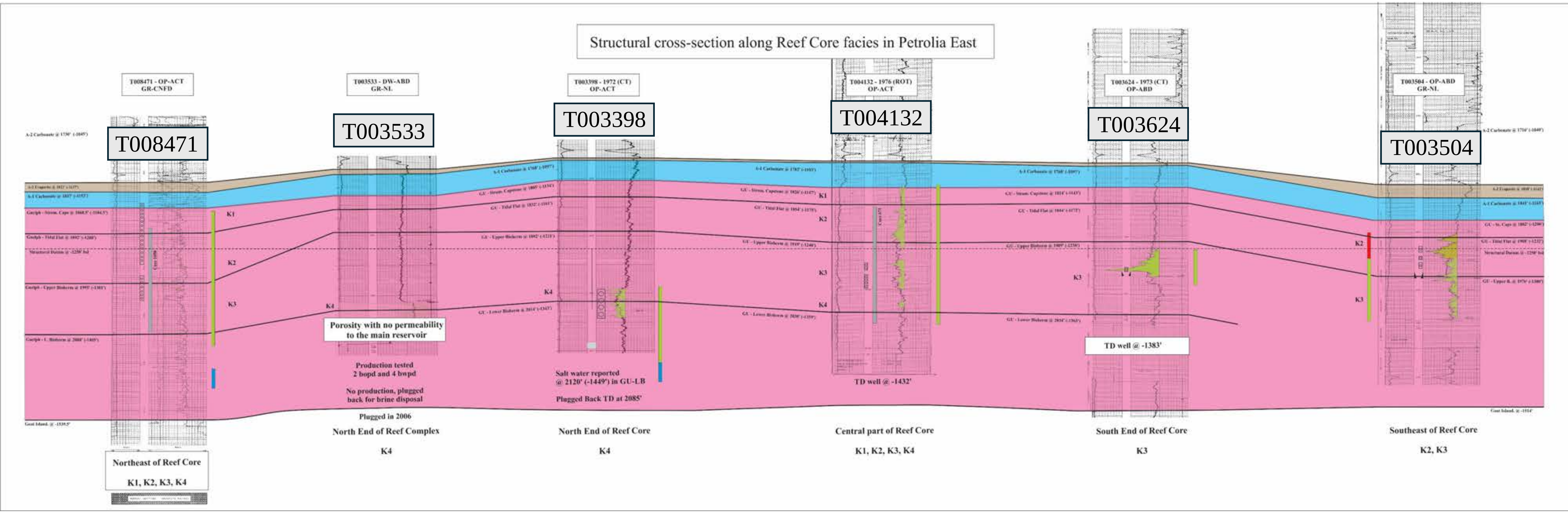




Petrolia East Oil Pools
Multiple reef bodies
Legend
Well logs used to create a cross-section
Prevailing winds out of NE
100’ contour
200’ contour
300’ contour
350’ contour
T008471
T003533
T003398
T004132
T003624
T003504
T005932
T003951
T008792
T003663
T005172
T006399
T003688
LOT 15 CON 10
LOT 16 CON 10
LOT 17 CON 10
LOT 18 CO
19 CON 10
N
2000 ft
Google Earth

Petrolia East Oil Pool – structural cross-section

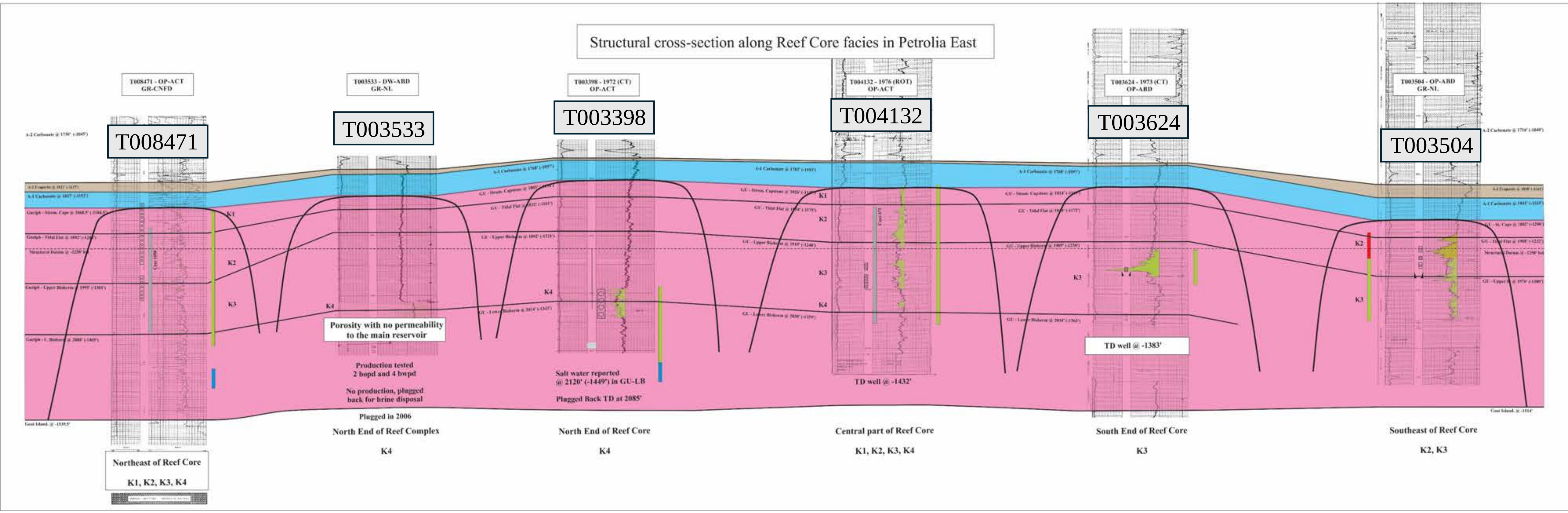
NE SE



IP 400 bopd 750 psig	No production BD-ABD	IP 150 bopd 843 psig	IP 40 bopd 901 psig	IP 125 bopd	IP 250 bopd 800 psig

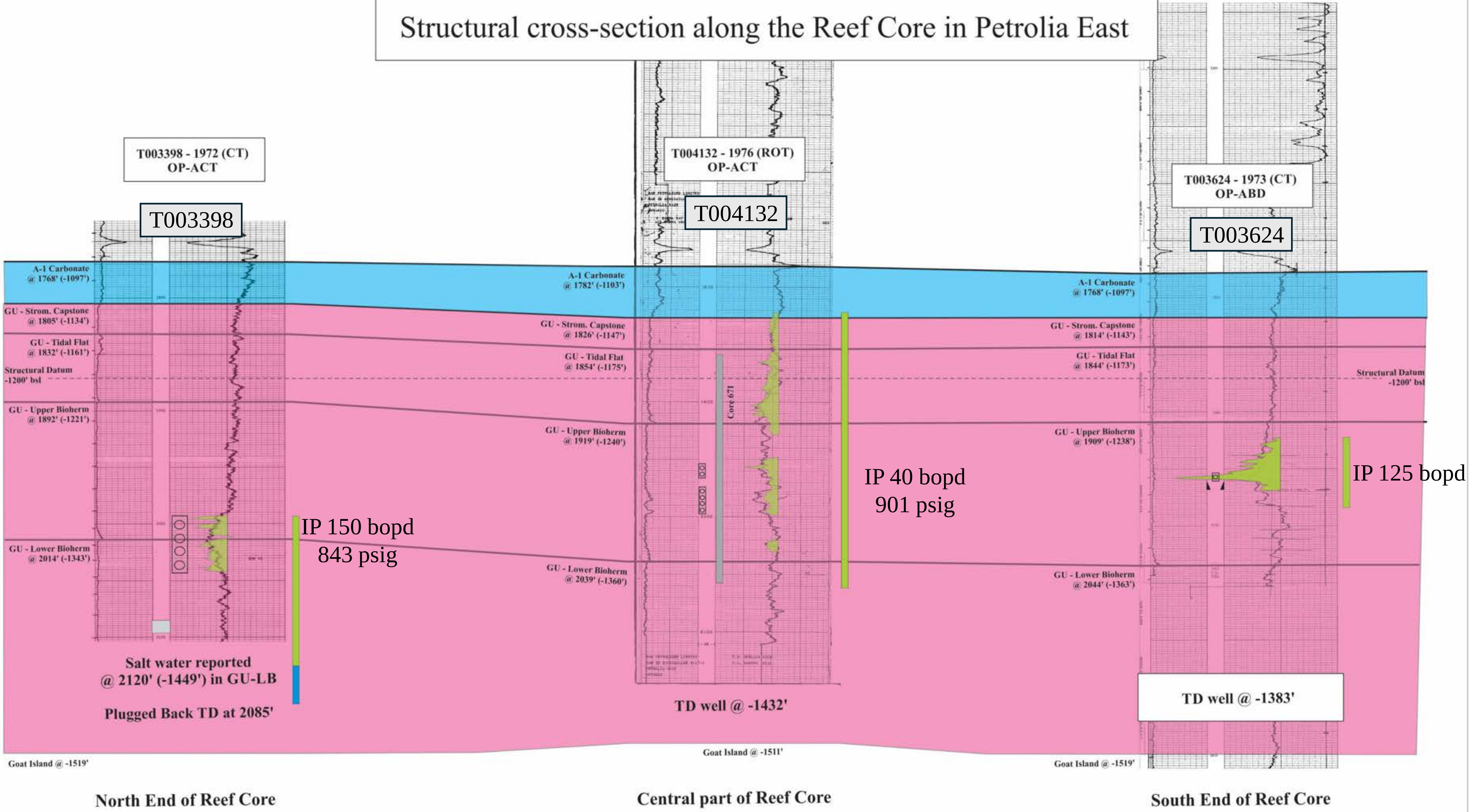
Petrolia East Oil Pool – structural cross-section

NE SE



IP 400 bopd 750 psig	No production BD-ABD	IP 150 bopd 843 psig	IP 40 bopd 901 psig	IP 125 bopd	IP 250 bopd 800 psig

Structural cross-section along the Reef Core in Petrolia East



Three wells within the Reef Core at Petrolia East

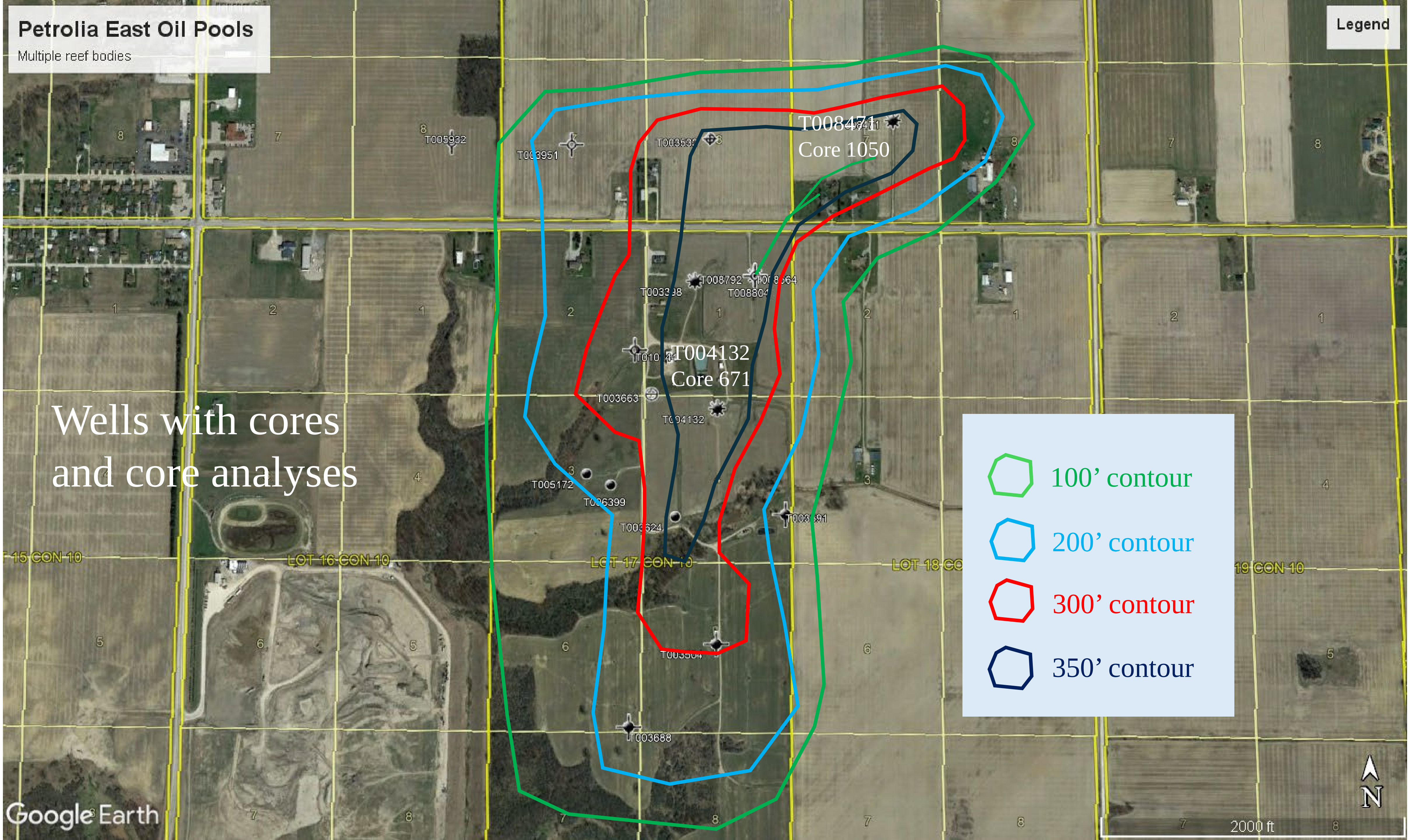
T003398 (north end of reef core) has reservoir development along the GU-UB (bottom 10’) and GU-LB (upper 30’) contact from 1993’ to 2043’ (-1322’ to -1372’); K4 karst level

T004132 was completed from 1954’ to 1966’ (-1275’ to -1287’) and 1974’ to 1997’ (-1295’ to -1318’) within the middle of the Upper Bioherm; K3 karst level

T004132 (central reef core) shows attic oil in the GU-TF facies, in a structurally higher reservoir compared to T003398; -1185’ to -1234’ (T004132) compared to -1322’ to -1372’ (T003398); K1 and K2 karst level

T003624 has reservoir development from the mid-Upper Bioherm (-1257’) down into the Lower Bioherm (-1383’), the well was completed open hole below 1968’ (-1297’) and later perforated from 1955’ to 1962’ (-1284’ to -1291’) within the middle of the Upper Bioherm; K3 karst level

Reservoir development within the main reef core occurs at different karst levels, which would make it difficult to plan a horizontal development well within this pinnacle reef complex


Petrolia East Oil Pools
Multiple reef bodies
Legend
Wells with cores
and core analyses
T008471
Core 1050
T004132
Core 671
T005932
T003951
T008792
T008804
T003663
T004132
T005172
T006399
T003688
LOT 16 CON 10
LOT 17 CON 10
100’ contour
200’ contour
300’ contour
350’ contour
N
2000 ft
Google Earth

Porosity and permeability of the Guelph Tidal Flat at Petrolia East

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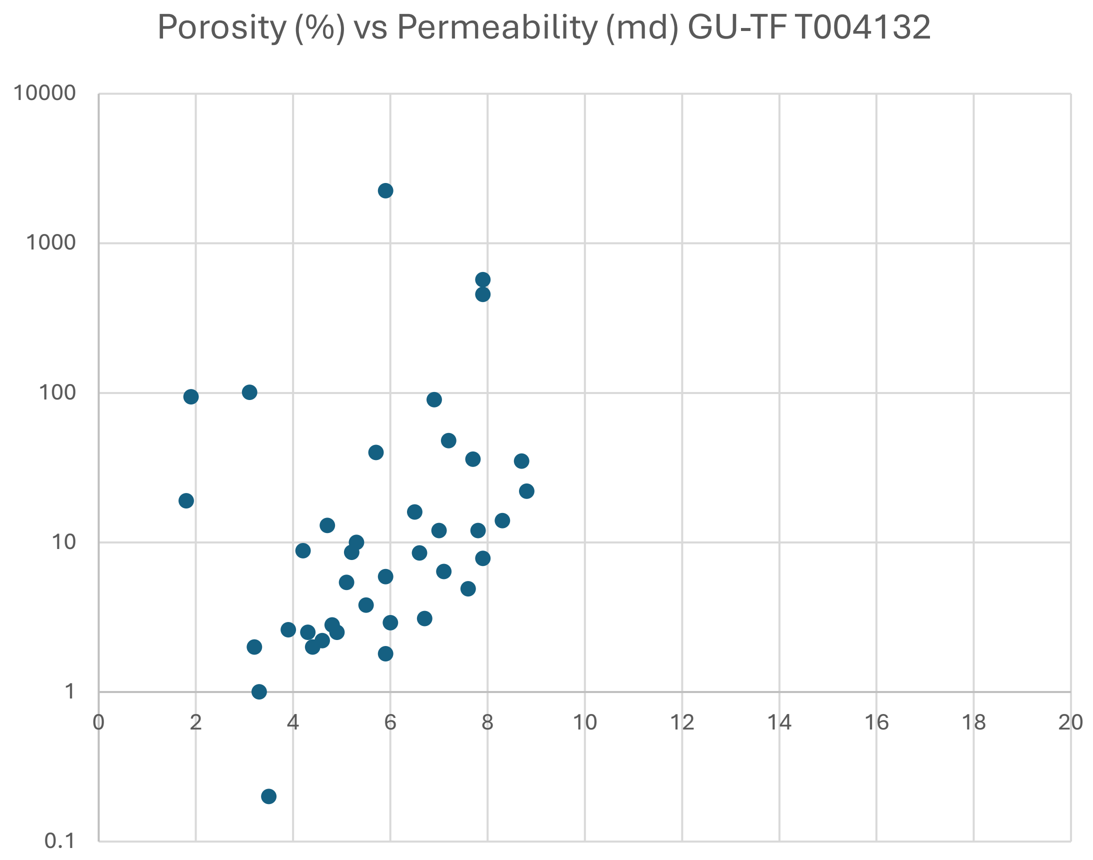
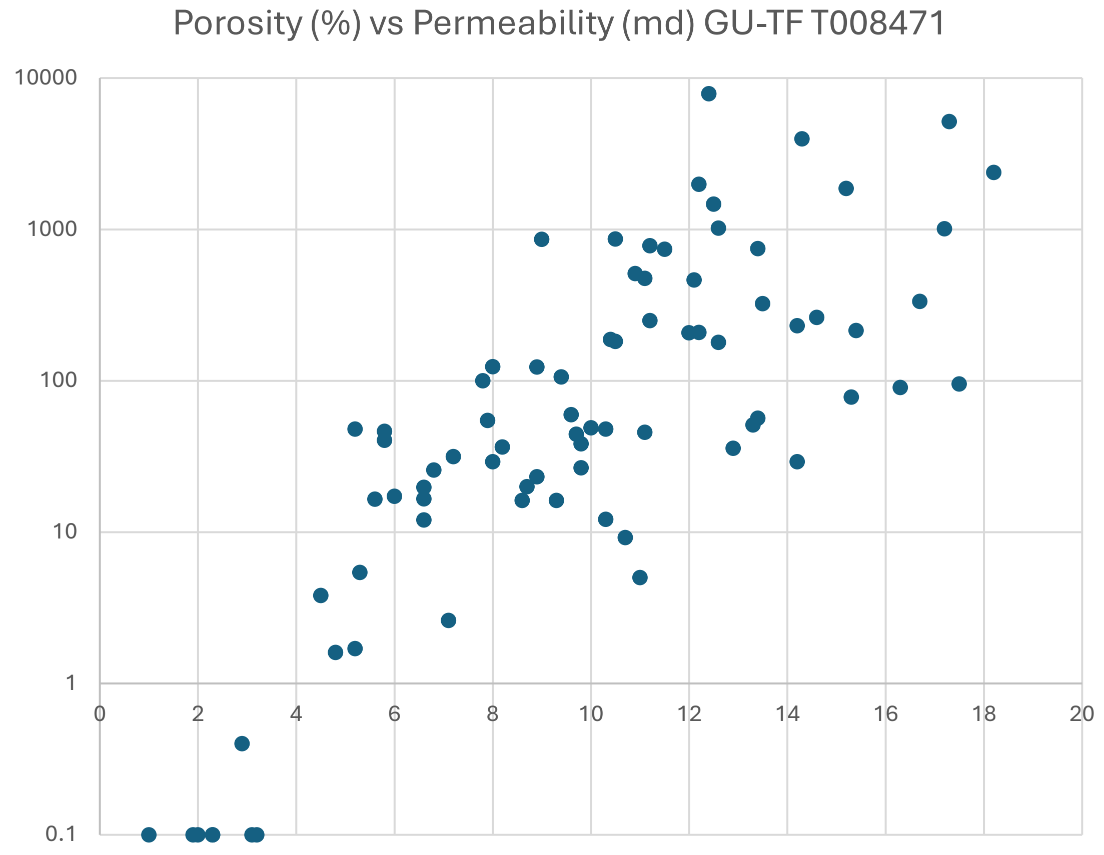
Petrolia East central reef core - T004132



Por (avg) 5.74 Perm (avg) 100.47

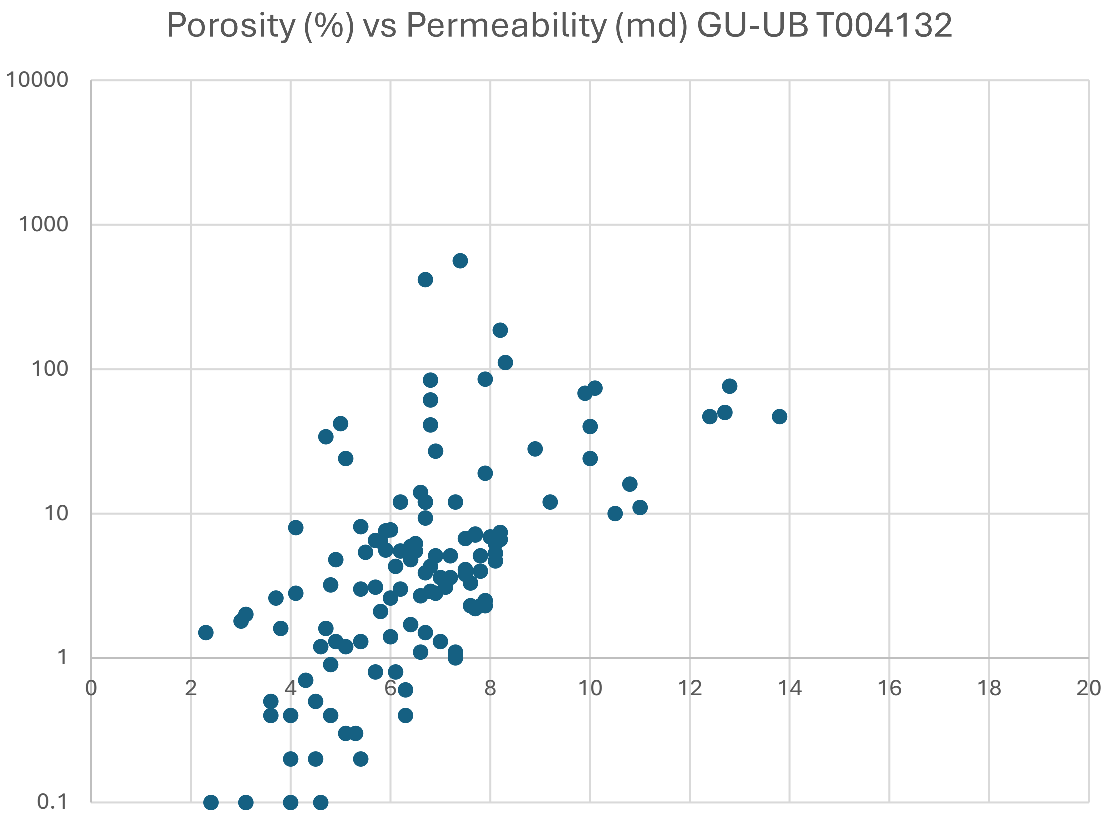
Petrolia East northeast bioherm – T008471



Por (avg) 9.77 Perm (avg) 460.65

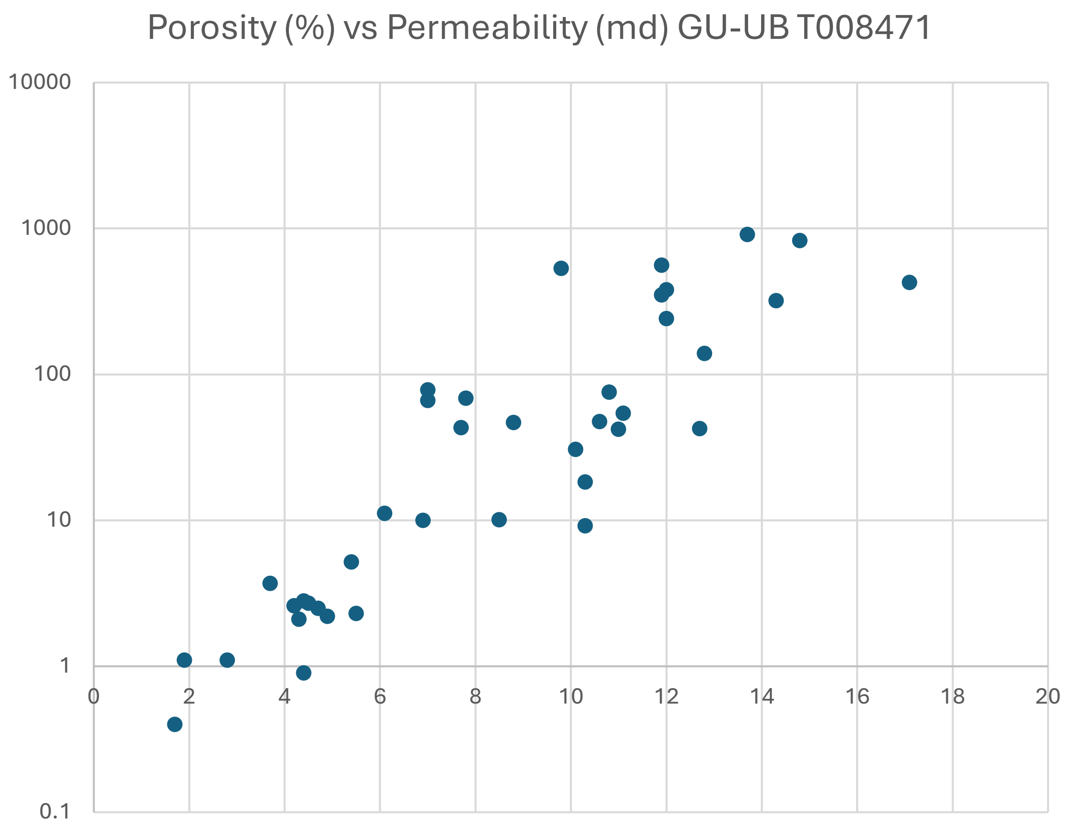
Porosity and permeability of the Guelph Upper Bioherm at Petrolia East

Petrolia East central reef core - T004132



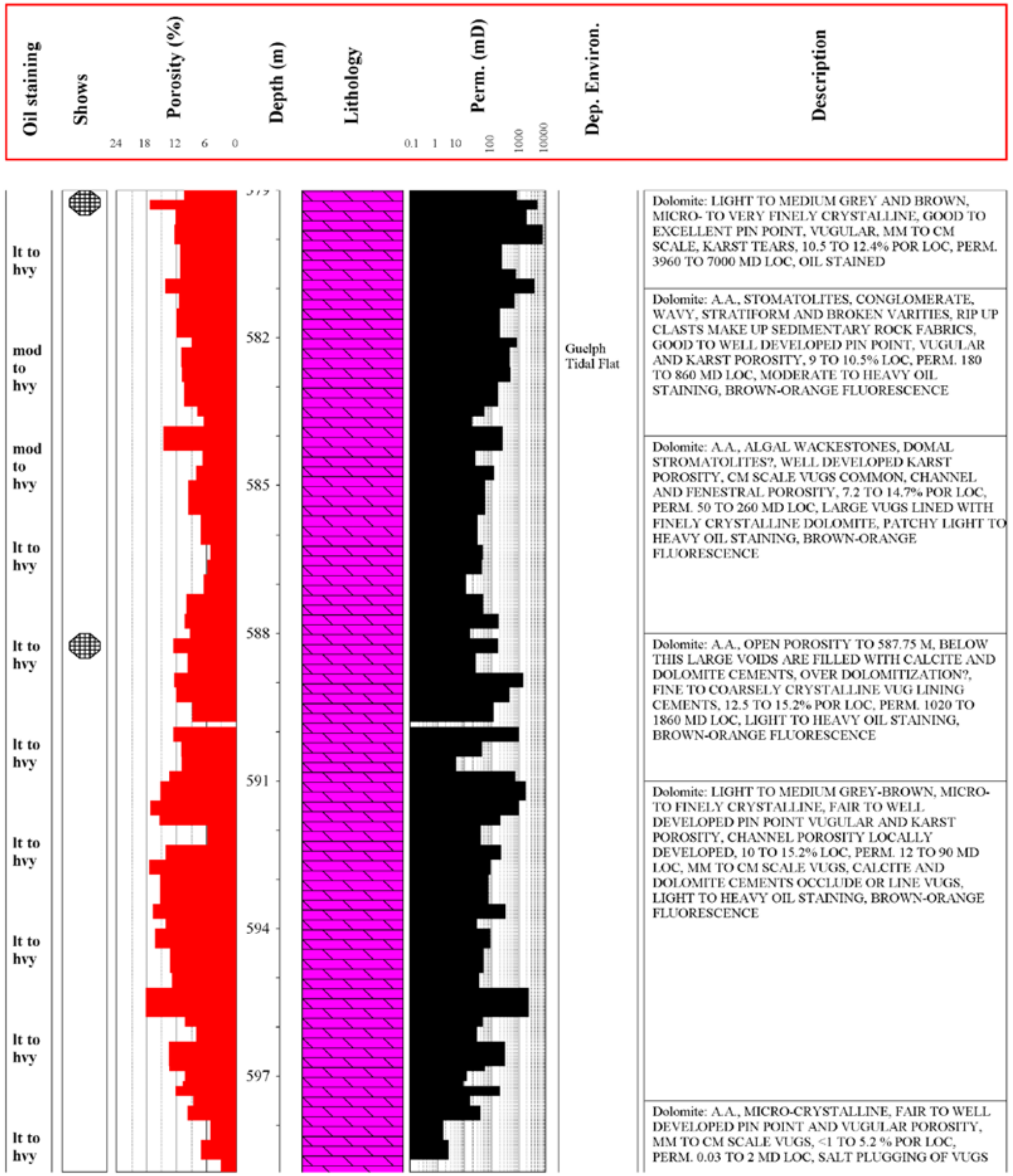
Por (avg) 6.62 Perm (avg) 21.16

Petrolia East northeast bioherm – T008471



Por (avg) 8.45 Perm (avg) 137.83

Well Name: Canenerco #3 **Well Location:** Enniskillen 7-18-XI
Elevations: Ground: 204.2 m **K.B.:** 208.6 m **Spud Date:** Dec. 28, 1996
Total Depth: 678.8 mKB PBTD **Status:** OP-ACT **Contractor:** Corunna Drilling Ltd.
Open Hole Logs: GR-CNFD-DLL-MLL-CBIL-BHC-AC
Cores and DST's: 579 to 633.4 mKB ; DST #1: 550 to 602 mKB
Geologist: Ian Colquhoun **Sample Interval:** 579 to 633.4 mKB **Sample Quality:** Excellent



Box 1: 579.1 to 580.1 mKB:
High permeability rocks

Box 3: 581.2 to 582.4 mKB
Wavy and stratiform stromatolites, domal stromatolites?

Box 4: 582.4 to 583.6 mKB
Stromatolites, conglomerate, boundstone, broken stromatolites

Box 6: 584.6 to 585.8 mKB
Stromatolites – domal?

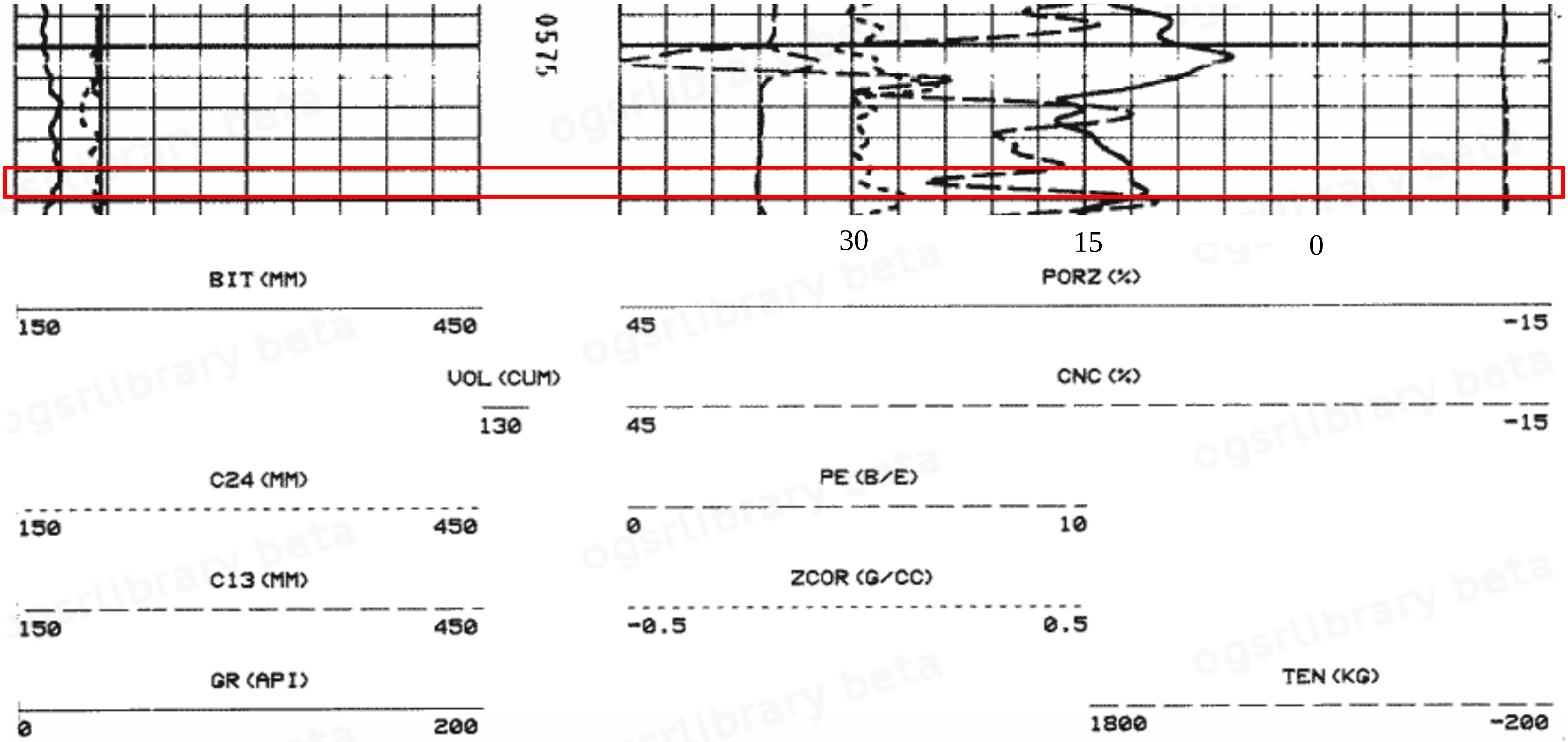
Box 8: 587 to 588.25 mKB
Filled and open pore space

Box 13: 592.6 to 593.8 mKB
Isopachous cements lining vugs

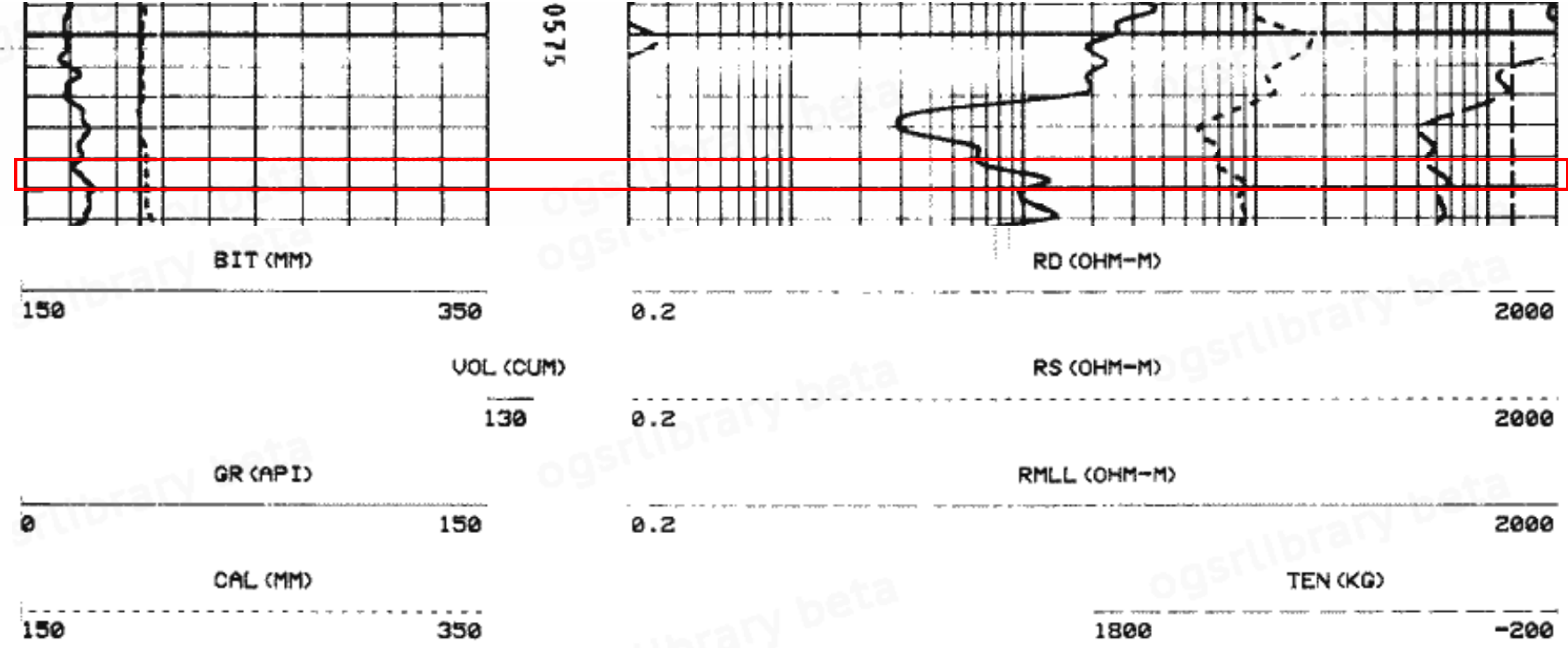
579 to 580 mKB: 10.5% porosity with 7000 mD permeability

Locally well-developed karst porosity and permeability with moderate to heavy oil saturation; rocks with high permeability are enclosed by rocks with smaller pore throats, which results in variable oil saturation of the rock.

Box 1: 579.1 to 580.1 mKB: High permeability rocks



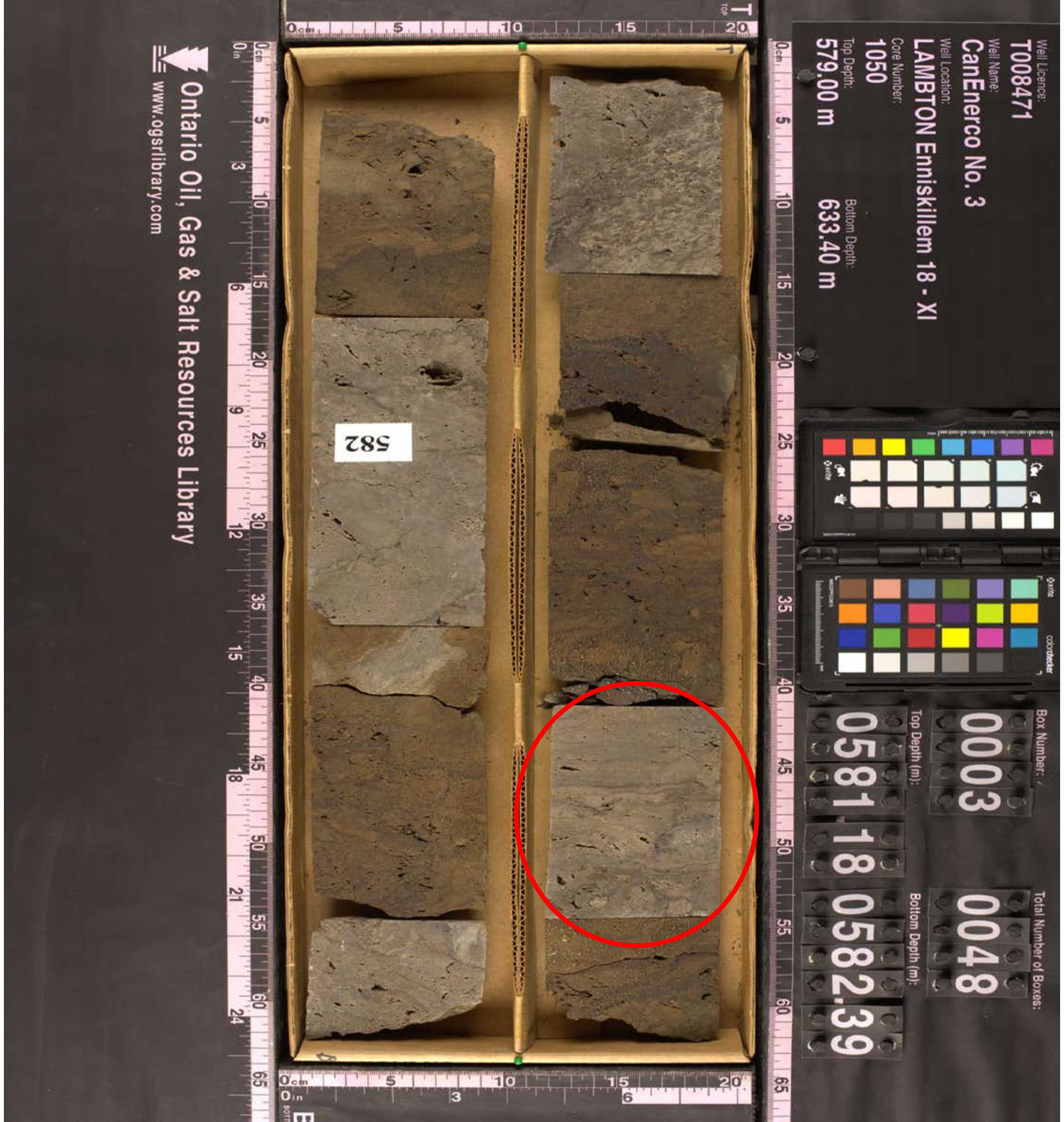
Box 1: 579.1 to 580.1 mKB: High permeability rocks



3-D Photography

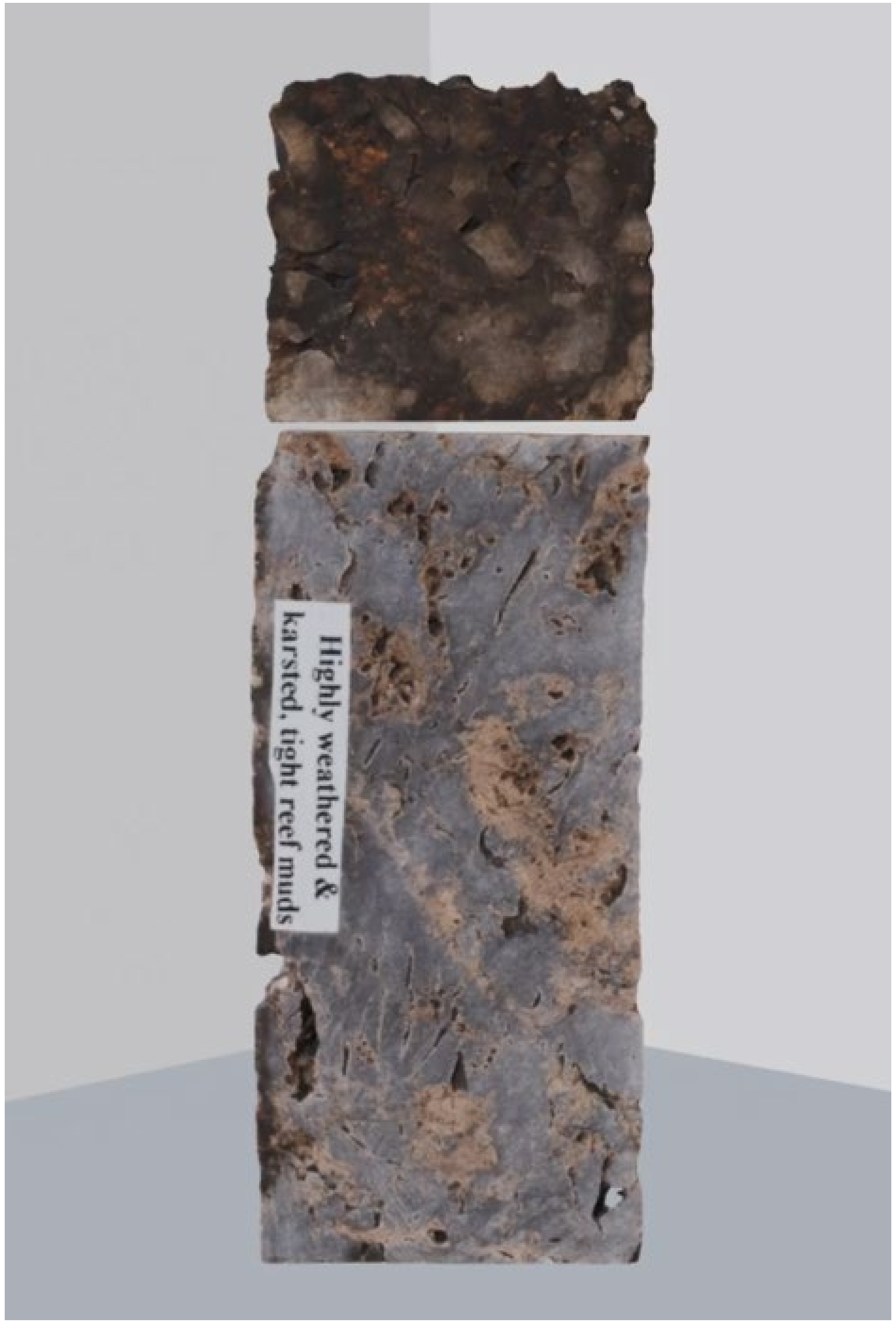
Box 1: 579.25 to 579.35 mKB
and 579.45 to 579.60 mKB

Karst tears and channel porosity



Wavy and stratiform stromatolites,
domal stromatolites?

Stromatolites, conglomerate, boundstone, broken stromatolites



3-D Photography

Box 4: 582.6 to 582.85 mKB and 582.85 to 583.0 mKB

Karst in dense muds with oil staining and without oil staining

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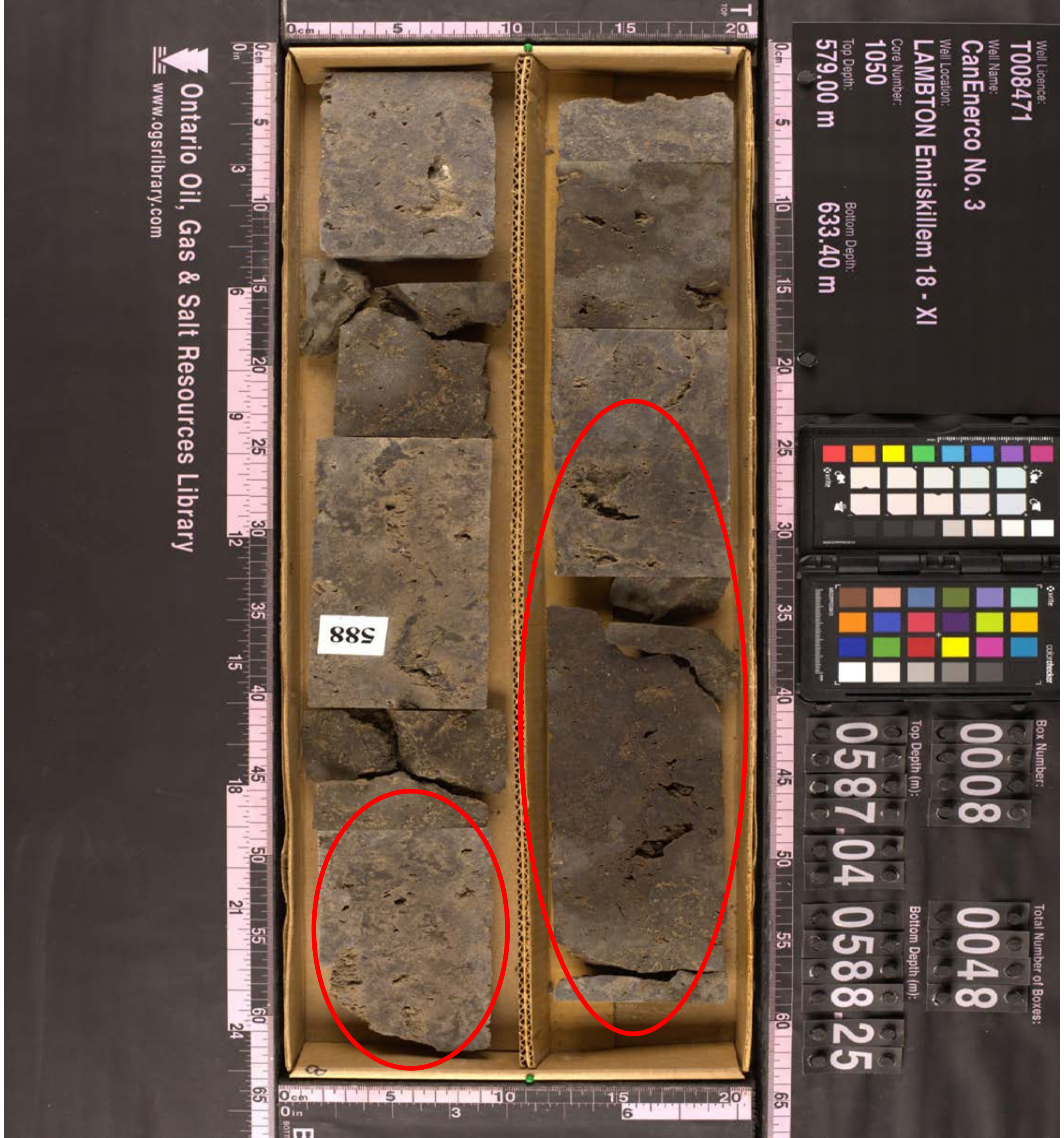
Stromatolites – domal or Stromatoporoid?



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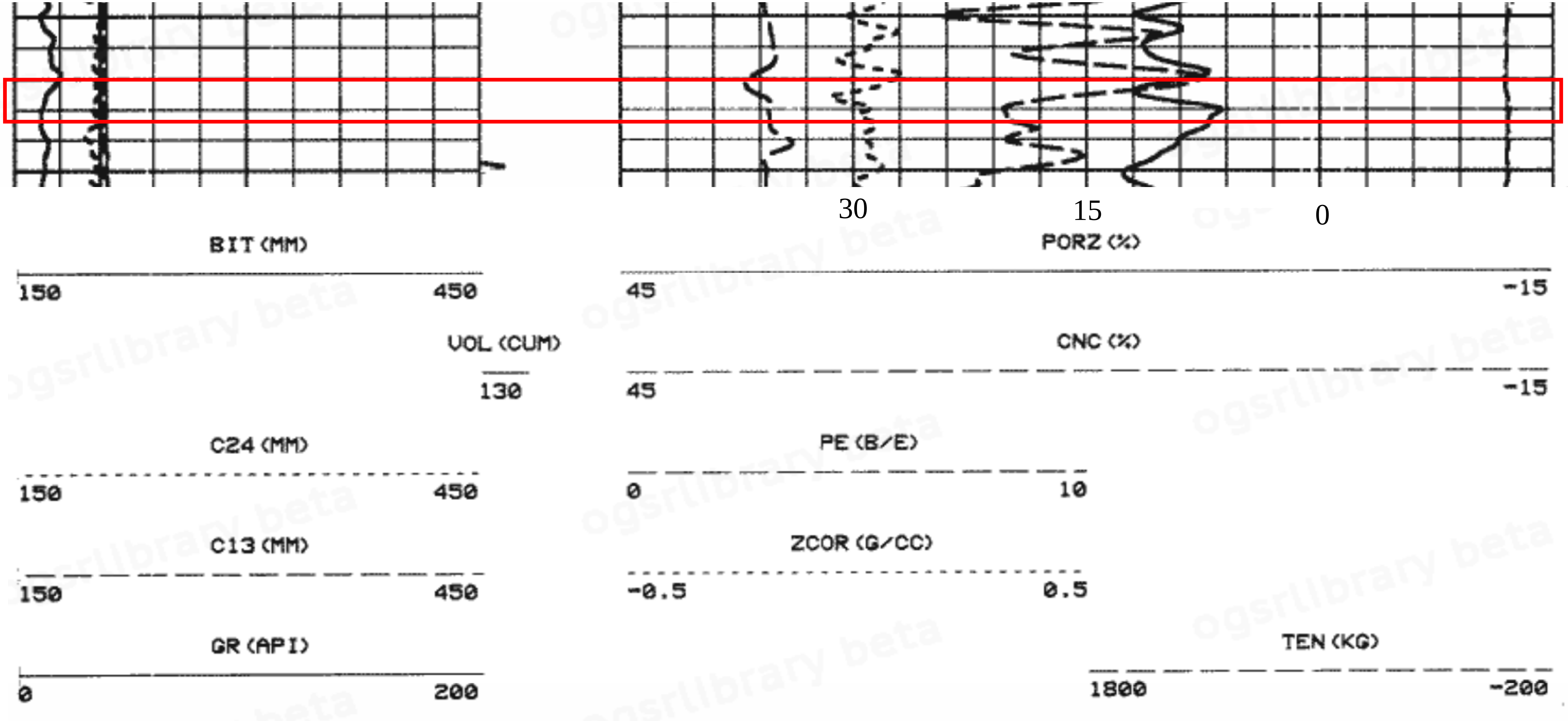
587 to 588 mKB: 6.6% porosity with 12 mD permeability; fair vuggy and inter-crystalline porosity and permeability; locally developed karst porosity, i.e., fenestral porosity.

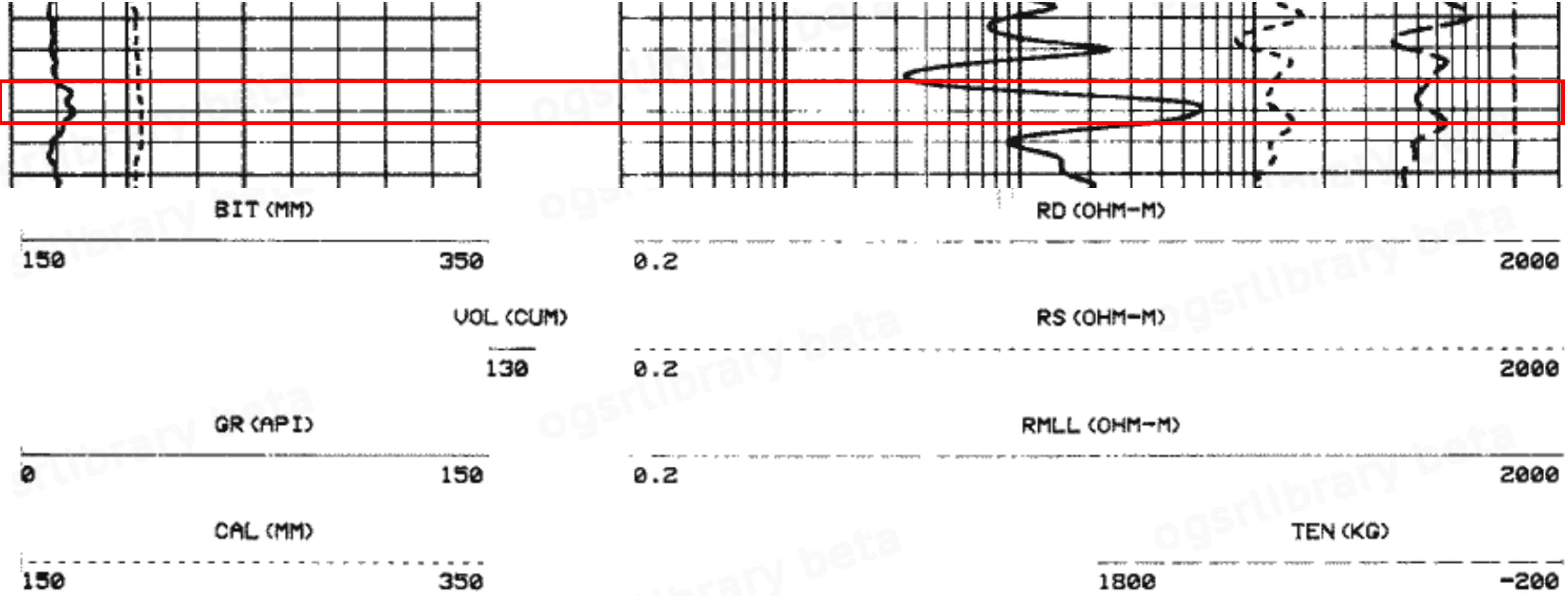
588 to 589 mKB: 9.3% porosity with 16 mD permeability: fair to good vuggy and inter-crystalline porosity and permeability.

Locally well-developed karst porosity, i.e., fenestral and channel porosity, fair to good vuggy and inter-crystalline porosity with and without oil saturation; rocks with highly variable permeability results in some degree of oil saturation showing that reservoir rocks are interbedded with tight rocks. This supports the interpretation that horizontal reservoir development is dominant over a well-connected vertical reservoir.

Box 8: 587 to 588.25 mKB: Filled and open pore space



Box 8: 587 to 588.25 mKB: Filled and open pore space



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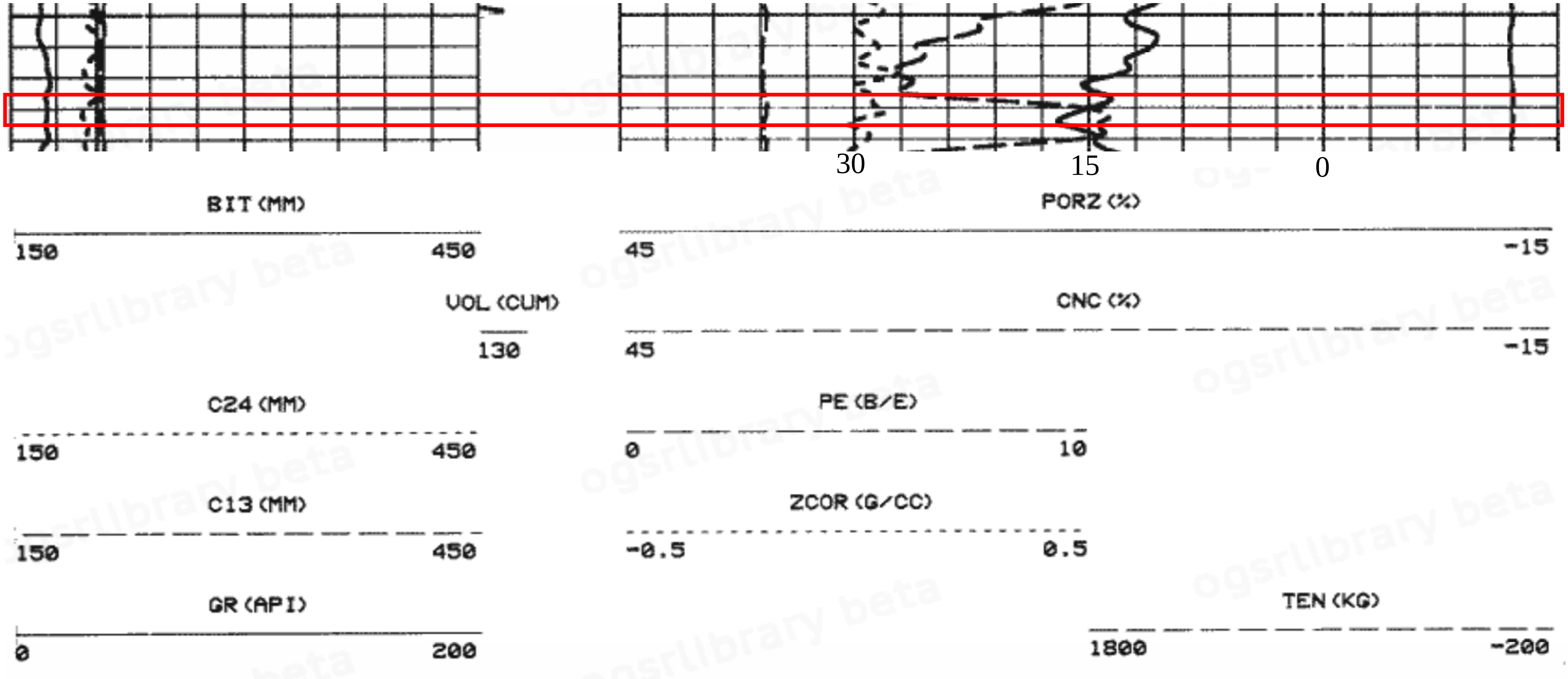
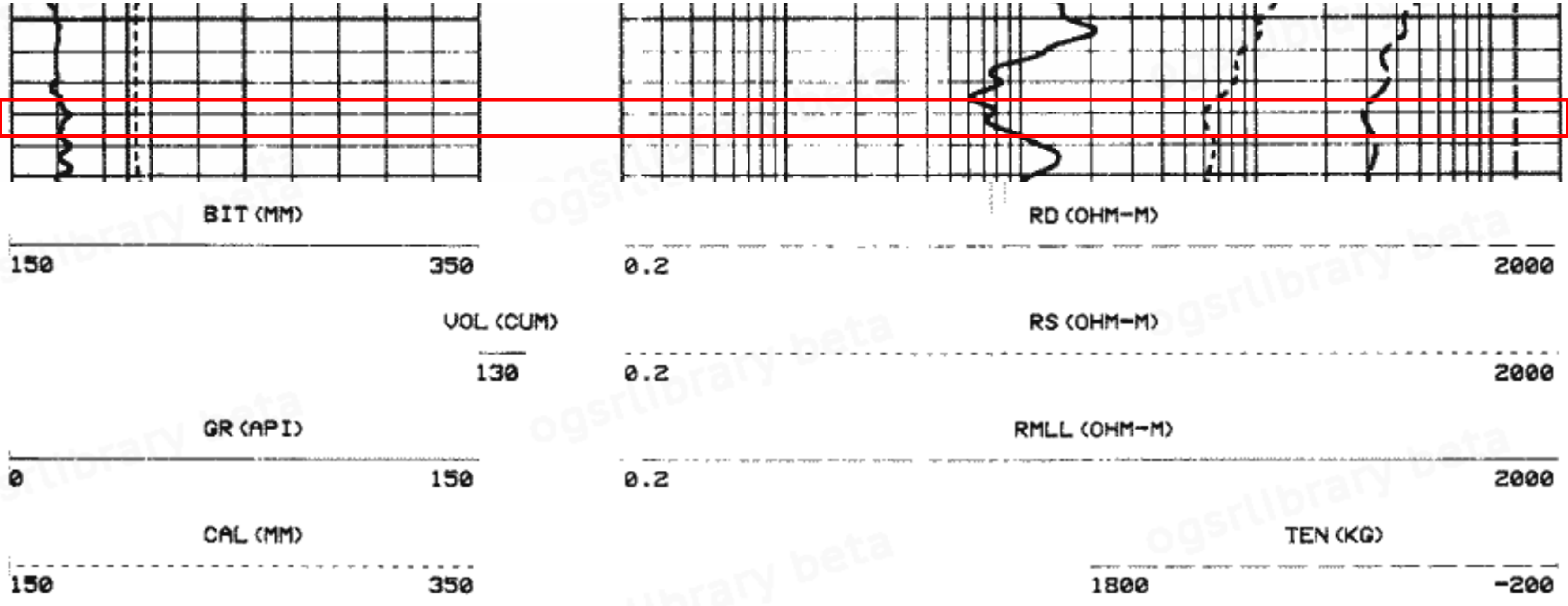
592 to 593 mKB: 15.2% porosity with 40 mD permeability; good vuggy and inter-crystalline porosity and permeability.

593 to 594 mKB: 18.3% porosity with 80 mD permeability: good to very good vuggy and inter-crystalline porosity and permeability. Light to heavy oil saturation that varies vertically supports horizontal reservoir development over a thick vertical reservoir. Stacking of reservoir and non-reservoir rocks.

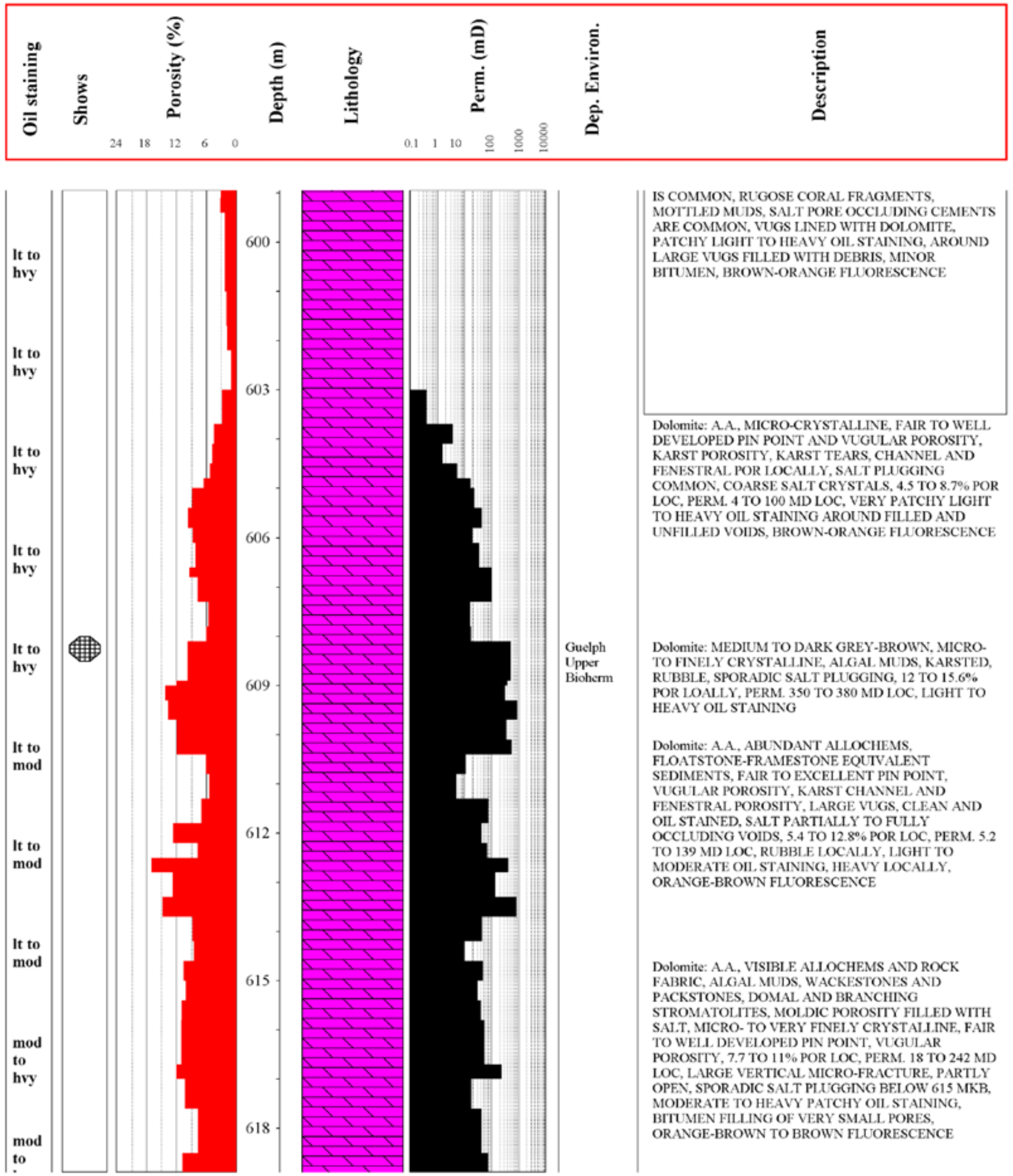
Box 8: 592.6 to 593.8 mKB: Isopachous cements lining vugs



Box 8: 592.6 to 593.8 mKB: Isopachous cements lining vugs



Well Name: Canenerco #3 **Well Location:** Enniskillen 7-18-XI
Elevations: Ground: 204.2 m **K.B.:** 208.6 m **Spud Date:** Dec. 28, 1996
Total Depth: 678.8 mKB PBTD **Status:** OP-ACT **Contractor:** Corunna Drilling Ltd.
Open Hole Logs: GR-CNFD-DLL-MLL-CBIL-BHC-AC
Cores and DST's: 579 to 633.4 mKB ; DST #1: 550 to 602 mKB
Geologist: Ian Colquhoun **Sample Interval:** 579 to 633.4 mKB **Sample Quality:** Excellent



Box 28: 609.6 to 610.8 mKB
Channel and fenestral porosity

Box 31: 613.3 to 614.4 mKB
Favosites coral?

Box 34: 616.6 to 617.7 mKB
Domal and branching stromatolites

Box 35: 617.7 to 618.8 mKB
Large sub-vertical micro-fracture, partly open

Channel and fenestral porosity created by local karst

Favosites coral?

3-D Photography

Box 31: 613.95 to 614.05 mKB

Salt-filled fenestral porosity and karst tears

Domal and branching stromatolites

Large sub-vertical micro-fracture, partly open

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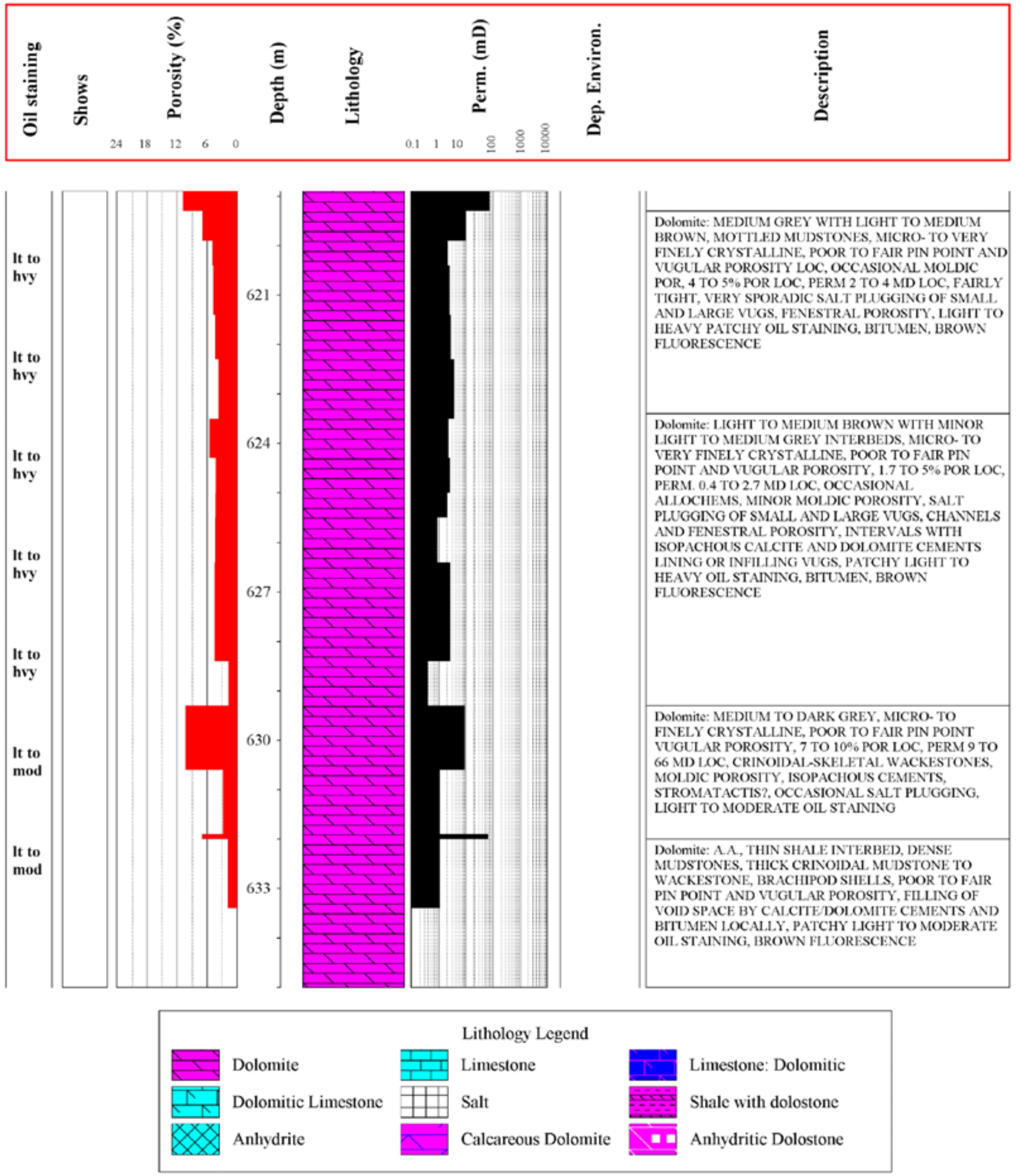

Box 43: 626.8 to 627.9 mKB
Destruction of pore space by salt plugging and bitumen

OPI 63[rd] Conference and Trade Show

Destruction of pore space by salt plugging and bitumen

epex 2026
OPI 63rd Conference and Trade Show

Rosedale Gas Storage Reef –
Enniskillen Twp., Lambton Co.
Core 578 (T003000A)

Box 11: 524.6 to 527.6 mKB;
Stromatoporoid boundstone and
broken stromatolites at 526.5 mKB

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Rosedale Gas Storage Reef – Enniskillen Twp., Lambton Co.
Core 578 (T003000A)

Box 17: 544.4 to 548.0 mKB;
Subaerial exposure at 545.6 mKB

Rosedale Gas Storage Reef –
Enniskillen Twp., Lambton Co.
Core 578 (T003000A)

Box 40: 618.7 to 621.8 mKB;
Skeletal wackestone at 620.9 mKB;
note the abundance of rugose corals

Rosedale Gas Storage Reef – Enniskillen Twp., Lambton Co. Core 578 (T003000A)

Box 42: 624.8 to 627.9 mKB; Stomatactis features (carbonate cements) at 627.3 mKB

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Warwick Oil Pool –
Warwick Twp., Lambton Co.
Core 526 (T010047)

Box 15: 526.7 to 529.7 mKB;

Fractured stromatolites at 527.5 mKB

Warwick Oil Pool –
Warwick Twp., Lambton Co.
Core 526 (T010047)

Box 49: 629.1 to 631.8 mKB; Coral Stromatoporoid facies at 629.3 mKB

Appendix I: Speakers Notes

Forward by Matt Rine

Title Slide: Using the Matt Rine model to better understand the Petrolia East Oil Reef (Ian Colquhoun - speaker)

#3: The Silurian Period began 443.8 mya and continued until 419.2 mya. North America once again witnessed a major transgression, the Tippecanoe transgression during the Middle Silurian, and it was responsible for the deposition of vast marine carbonates in the form of reefs (barrier, patch and pinnacle reefs), as well as marine shales and evaporate deposits. The picture on the right displays the typical reef biota that flourished at this time, including several forms of Tabulate coral, branching bryozoans, rugose coral, brachiopods, trilobites and cephalopods.

#4: The most underrated but most important form of biota within the shallow marine environment was algae that flourished in many reef environments, patch and pinnacle reefs, providing tabular, encrusting and domal forms of stromatolites; you will see several varieties of stromatolites in the core.

#5: Let’s travel back to the Middle Silurian, ~425 mya, Gondwana was lying along the south pole and Laurentia, or North America, was lying just south of the equator.

#6: The Michigan Basin was about 15 degrees south of the equator and formed within a large inland sea that was open to the vast Paleo-Tethys Sea via a long and narrow seaway. You will notice that this was also true for the Appalachian and Illinois Basins.

#7: The continental land mass and the inland seas were subject to prevailing wind directions out of the SSE, which provided the counterclockwise rotating water current in the Paleo-Tethys Sea.

#8: Trade winds came across the Appalachian Mountains in response to the Coriolis effect influenced by the local and regional topography.

#9: The predominate wind direction has been rotated along with the North American continent from an SSE direction to an ENE-WSW orientation. Note that the pinnacle reefs in the northern and southern pinnacle reef trends are aligned along this ENE-WSW direction.

#10: This diagram shows generalized pinnacle reef heights for pinnacle reefs from both the northern and southern pinnacle reef belts in the Michigan Basin (Matt Rine). A very gentle slope was determined to be responsible for the pinnacle reef heights on both sides of the Michigan Basin.
#11: The bioherm or lower Guelph had undergone karst exposure at different levels in the reefs based upon their position within the pinnacle reef basin. This is known as the original karst event that occurred prior to deposition of the Upper Guelph (bioherm).

#12: Sea level experienced a rapid rise during the deposition of the Upper Guelph, and this is known as the “keep up stage”.

#13: Karst of the ramp tops and pinnacle reefs occurred as sea level fell, prior to the deposition of the A-1 Salt. This was responsible for the development of 6 more intense but localized karst events that can be observed within the cores taken from pinnacle reefs.

#14: The depositional environments for the Lower and Upper Guelph were interpreted from core samples and are constrained by their carbon-13 isotopic excursions; these excursions help define the placement of major sequence boundaries (sea level changes). This is foundational work done by Matt Rine that helps exploration geologists understand how to separate these depositional environments when all that we must work with is geophysical logs and chip samples.

#15: This is a SW to NE transect through the Columbus III Field (B to B’) that illustrates the depositional environments encountered for the Guelph across the pinnacle reef complex.

#16: This is a SW to NE vertically exaggerated (3:1) cross-section through Columbus III reef showing the major reef depositional environments along a six well transect; cross-section is flattened on the underlying Gray Niagaran or Lockport Group. We have the Lower Guelph or bioherm, which is overlain by the Reef Core or the Reef Apron on the westerly flank side of the reef. The Proximal Foreslope is on the east side of the reef and is very steeply dipping.

#17: Now we are going to focus on a relatively small area of the Michigan Basin in SW Ontario. We have Barrier and Patch reefs along the Algonquin Arch, and the pinnacle reef belts along the northern and southern basin slope.

#18: We will now focus on a very small area of the pinnacle reef belt, where oil reefs are known to be more common. An area between Corey East in the SW to Grand Bend in the NE. Some of these pinnacle reefs have been very prolific oil producers.

#19: We will now zoom in on one pinnacle reef, Petrolia East, where we have a reasonable amount of geological data that will help us understand why certain wells produced oil and others did not, using an understanding of Matt’s pinnacle reef depositional model. This image shows the wells drilled into Petrolia East, I have illustrated the thickness contours for the Guelph and noted the year the well reached total depth and were completed as oil producers.

#20: This spreadsheet is presented to show the typical data and lack of data when studying pinnacle reefs, first is the Lockport Group (Goat Island) top beneath the reefs. Very few wells drilled into pinnacle reefs drill all the way through to the Lockport Group below. You will notice that the projected depth to encounter the Goat Island at the northeast end of Petrolia East (T008471) is projected to be lower than the regional top (T005932). Faulting may be responsible for this. You will also notice that very few wells have reservoir pressure data, normally acquired thought DST's or early production testing results. But for those that do, there is a great story to tell.

#21: This image shows the Petrolia East pinnacle reef with thickness contours; the Guelph thickness encountered at each well and the initial production rates or IPs. What you will notice is that the wells that encountered thicker Guelph along the central reef position were productive, and flank wells were not productive. The adage of "drilling a crestal position" to find oil production couldn't be more accurate. Matt identified the main productive portion of the Guelph as the Reef Core.

#22: Seven wells found some amount of oil production (white) and four wells are still producing oil today (yellow) at Petrolia East. The wells that are producing oil today are located within a very narrow area on the crestal portion of the reef, these wells are in the "Reef Core" depositional environment within the reef complex. If we were blessed with rock cores for each of these wells, then we could show you this in more detail.

#23: This slide shows the location of six wells, where I have created a transect through the middle of Petrolia East pinnacle reef (bounded by the 300' Guelph thickness contour) to create a structural cross-section that shows reservoir development across the pool.

#24: A structural cross-section using the geophysical logs from the six wells. We will start in the northeast, well T008471 was incredibly productive and the oil reservoir was mainly in the Upper portion of the Guelph. Several cores taken from this well are in front of you today. The well immediately to the west, T003533, did not encounter any reservoir although it was completed as if the operator believed that they found an oil zone. Does that sound familiar to anyone here? The well directly south, T003398, encountered reservoir at the contact of the Upper and Lower Guelph. Further south, T004132, the well encountered oil production from the middle of the Upper Guelph. It appears that an oil reservoir may also be present at the top of the Upper Guelph. Directly south, T003624 encountered a reservoir in the middle of the Upper Guelph, finally a little consistency from well to well. T003504 at the south end of this cross-section encountered an oil and gas reservoir near to top of the Guelph. Imagine if you were told to place a horizontal well through the productive portion of this reef. Where would you put it?

#25: Ram Petroleum discovered the Petrolia East Oil Pool in 1972 and in 1979 presented a paper at the annual OPI conference. The paper was authored by Bob Trevail, entitled "The geology and production history of the Petrolia East Pool". In the paper, Bob stated, "There is a strong possibility that each well is draining its own separate oil pool. Fluid level measurements, taken after each well had been shut-in for a period of time, gave no indication for a uniform bottom hole pressure in the field." Each oil well behaved as if it intersected a separate reservoir.

#26: A close-up look at the three Reef Core wells within the central part of Petrolia East shows the oil reservoir located at different parts of the Guelph and with different initial reservoir pressures. The shut-in pressures are different, but more importantly that the completion and reservoir maintenance activities performed at one well did not interfere or influence the fluid level or formation pressures at nearby wells.

#27: This slide summarizes that reservoir development observed for the 3 wells in the main reef core, it occurs at karst different levels within the Guelph which would make it difficult to plan a horizontal development well within this pinnacle reef complex.

#28: This map shows the location of two wells where several cores with core analyses were taken at Petrolia East. We are going to focus our attention, in this workshop, on Core 1050 from T008471 from the northeast part of the pinnacle reef complex.

#29: We wanted to show you the plots of porosity vs permeability for the two cores before we review of the rock cores from T008471. The x and y axis scales are the same for all plots so that you can visually observe the differences in porosity and permeability for the Tidal Flat and Upper Guelph (bioherm) depositional environments between the two wells.

Porosity and permeability for the Tidal Flat depositional environment at T008471 shows more scatter or a larger range of variation, accounting for higher porosity and permeability on average compared to T004132 from the central Reef Core.

#30: The same can be said for the Upper Guelph (bioherm) depositional environment. So why the great difference between the two wells? The effect of karst and a fully dolomitized reservoir created exceptional porosity and permeability at Petrolia East. These effects are more pronounced at the north end of the reef complex, where the reef was exposed to karst along the prevailing wind direction. Did faulting influence the creation of exceptional porosity and permeability? T008471 has a similar Guelph thickness compared to nearby wells but is observed to be structurally lower than those wells.

#31: A lithological strip log and core photos from the Tidal Flat depositional environment at T008471. We see several features in the core that will help us understand these rocks and the reservoir that was developed.

#32: Box 1: 579.1 to 580.1 mKB; High permeability rocks. Locally well-developed karst porosity and permeability with moderate to heavy oil saturation; rocks with high permeability are enclosed by rocks with smaller pore throats, which results in variable oil saturation of the rock.

#33: Porosity logs over 579.1 to 580.1 mKB interval showing reverse cross-over in the highly porous and permeable interval.

#34: Resistivity logs over 579.1 to 580.1 mKB interval showing micro, shallow and deep resistivity curves. Micro is 10 to 15 ohm/m reflecting the resistivity of drilling brine; shallow is 70 to 90 ohm/m responding to invasion of drilling brine in the presence of oil; deep is 500 to 600 ohm/m showing a good oil resistivity response.

#35: 3-D Photography; Box 1: 579.25 to 579.35 mKB and 579.45 to 579.60 mKB; Karst tears and channel porosity at 579.5 mKB

#36: Box 3: 581.2 to 582.4 mKB; Wavy and stratiform stromatolites, and domal stromatolites? at 581.65 mKB

#37: Box 4: 582.4 to 583.6 mKB; Stromatolites, varieties include conglomerate, boundstone, and broken stromatolites at 582.9 mKB

#38: 3-D Photography; Box 4: 582.6 to 582.85 mKB and 582.85 to 583.0 mKB; Karst in dense mud with oil and without oil staining

#39: Box 6: 584.6 to 585.8 mKB; Stromatolites – domal? Or a domal stromatoporoid with no internal structure? at 585.6 mKB

#40: Box 8: 587 to 588.25 mKB; Filled and open pore space at 587.3 mKB and 587.9 mKB.

587 to 588 mKB: 6.6% porosity with 12 mD permeability; fair vugular and inter-crystalline porosity and permeability; locally developed karst porosity, i.e., fenestral porosity.

588 to 589 mKB: 9.3% porosity with 16 mD permeability: fair to good vugular and inter-crystalline porosity and permeability.

Locally well-developed karst porosity, i.e., fenestral and channel porosity, fair to good vuggy and inter-crystalline porosity with and without oil saturation; rocks with highly variable permeability results in some degree of oil saturation showing that reservoir rocks are interbedded with clean, tight rocks. This supports the interpretation that horizontal reservoir development is dominant over a well-connected vertical reservoir.

#41: Porosity logs over 587.0 to 588.25 mKB interval showing porosity cross-over with 9 to 12% porosity.

#42: Resistivity logs over 587.0 to 588.25 mKB interval showing micro, shallow and deep resistivity curves. Micro resistivity 50 to 60 ohm/m indicates the presence of drilling brine; medium is 120 to 150 ohm/m and deep is 500 to 600 ohm/m, both responding to the resistivity or presence of oil.

#43: Box 13: 592.6 to 593.8 mKB; Good porosity and permeability, variable oil saturation is evidence that horizontal reservoir development is dominant over a well-connected vertical reservoir. Isopachous cements lining vugs at 593.0 mKB.

592 to 593 mKB: 15.2% porosity with 40 mD permeability; good vuggy and inter-crystalline porosity and permeability. Micro resistivity indicates the presence of drilling brine while medium and deep resistivity are reflecting the presence of hydrocarbons (oil).

593 to 594 mKB: 18.3% porosity with 80 mD permeability: good to very good vuggy and inter-crystalline porosity and permeability. Light to heavy oil saturation that varies vertically supports horizontal reservoir development over a thick vertical reservoir. We observe a vertical stacking of reservoir and non-reservoir rocks.

#44: Porosity logs over 592.6 to 593.8 mKB interval showing porosity cross-over with 15% porosity.

#45: Resistivity logs over 592.6 to 593.8 mKB interval showing micro, shallow and deep resistivity curves. Micro resistivity 6 to 10 ohm/m responding to the presence of drilling brine; medium is 60 to 70 ohm/m responding to invasion of drilling brine in the presence of oil; deep is 300 ohm/m in response to the presence of oil. All three zones contain oil and formation water in differing saturations (see core analysis).

We move onto the lithological log and core photos from the Upper Guelph (bioherm)

#46: Lithological strip log of the Guelph Upper Bioherm

#47: Box 28: 609.6 to 610.8 mKB; Channel and fenestral porosity at 609.7 to 610.0 mKB

#48: Box 31: 613.3 to 614.4 mKB; Is this the remnants of a Favosites coral? at 613.5 mKB

#49: 3-D Photography; Box 31: 613.95 to 614.05 mKB; Salt-filled fenestral porosity and karst tears and absence of salt in similar porosity below. Is this evidence for selective removal of salt?
#50: Box 34: 616.6 to 617.7 mKB: Domal and branching stromatolites at 616.9 mKB

#51: Box 35: 617.7 to 618.8 mKB: Large sub-vertical micro-fracture that is partly open. Micro-fractures may be the conduits for fluid movement throughout the pinnacle reefs, up into the reef core and along well-developed karst horizons.

#52: Lithological strip log of the Guelph down to the end of core

#53: Box 43: 612 to 613.3 mKB; Destruction of pore space by salt plugging and bitumen at 627.05 and 627.85 mKB

Additional features observed in cores at Rosedale and Warwick

Rosedale – Core 578 – T003000A

#54: Box 11: 524.6 to 527.6 mKB; Stromatoporoid boundstone and broken stromatolites at 526.5 mKB

#55: Box 17: 544.4 to 548.0 mKB; Subaerial exposure at 545.6 mKB

#56: Box 40: 618.7 to 621.8 mKB; Skeletal wackestone at 620.9 mKB; note the abundant rugose corals

#57: Box 42: 624.8 to 627.9 mKB; Stomatactis features (carbonate cements) at 627.3 mKB

Warwick – Core 526 – T010047

#58: Box 15: 526.7 to 529.7 mKB; Fractured stromatolites at 527.5 mKB

#59: Box 49: 629.1 to 631.8 mKB; Coral Stromatoporoid facies at 629.3 mKB

A future core workshop will include the cores from a limestone reef (Rosedale), a partially dolomitized reef (Warwick) and a fully dolomitized reef (Petrolia East and/or Corey East) to demonstrate that horizontal permeability and reservoir development are present in these reefs and is likely to be encountered in all pinnacle reefs. This has great implications for drilling and completion of pinnacle reefs for all kinds of storage applications.