epex 2025
OPI 62nd Conference and Trade Show

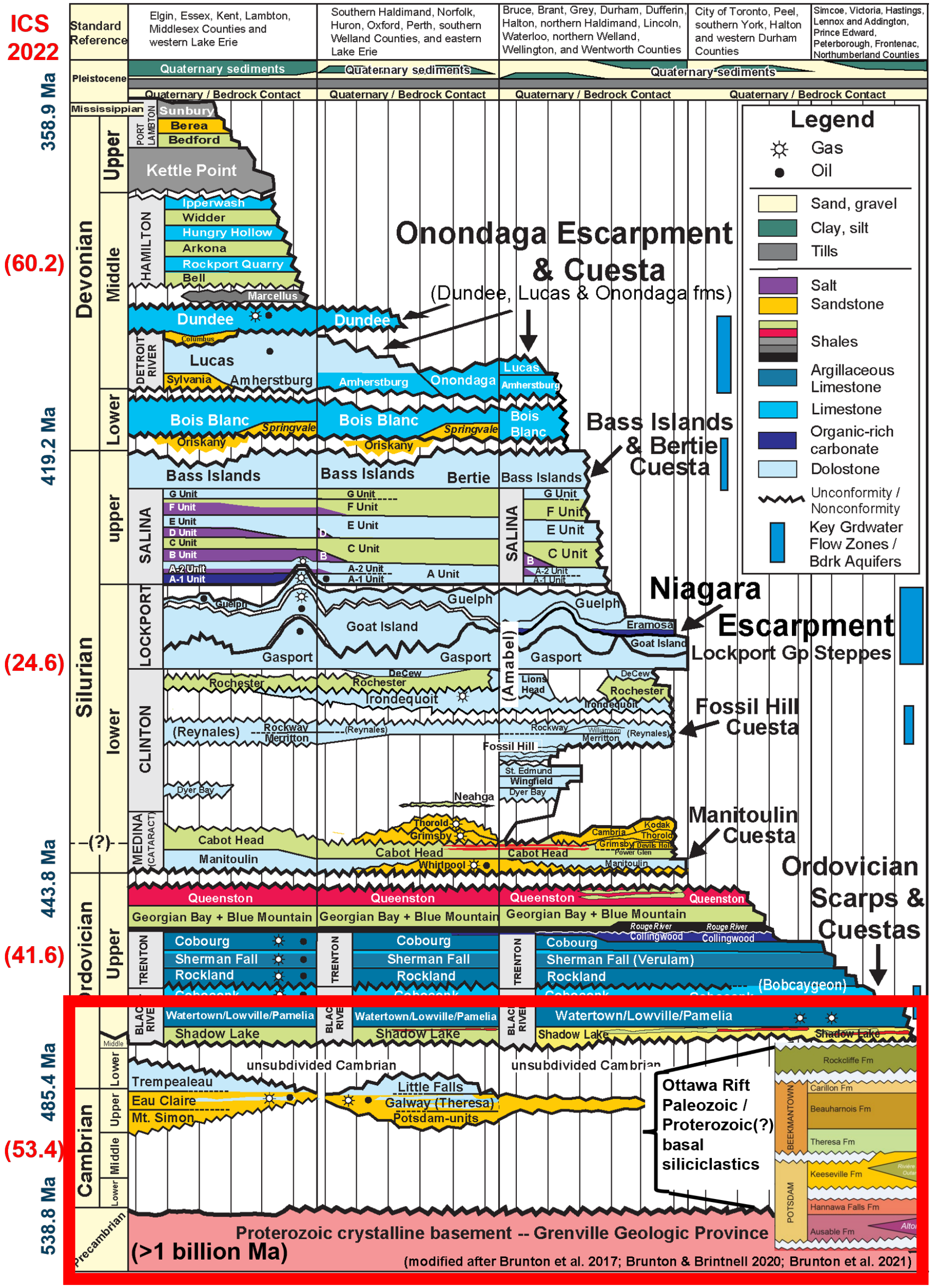
Cambrian subsurface of southwestern Ontario: competition for pore space

Allan R. Phillips & Frank R. Brunton

Clinton-Medina Group & Ontario Geological Survey

Introduction:

- This core workshop presentation is part of a multi-year co-operative study between the Ontario Geological Survey (Ministry of Energy and Mines-MEMS) and Petroleum & Regional Operations Divisions of the Ministry of Natural Resources – OGS Project SO-22-004.
- It involves the examination of basal Paleozoic sedimentary rocks and underlying weathered metasedimentary and crystalline Proterozoic basement in key wells across southwestern Ontario.
- The Cambrian formation names currently in use within OPDS and OGS are from Sanford & Quillian (1959; GSC Paper 58-12). They subdivided the Cambrian succession into 3 different rock units within southwestern Ontario. The Michigan Structural Basin western portion having different names than the Appalachian Foreland Basin southeastern portion.
- In the 65 years since their publication more than 900 wells have been drilled into this interval.



Brunton (2024) OGS Virtual Showcase

Early Subsurface mapping of Cambrian in SW Ontario

Sanford & Quillian (1959) used drillers reports from 200 Ontario wells –
130 sets of drill cuttings and one core to create a suite of maps for southwestern Ontario.
Cross-sections extended into adjoining states for correlation.

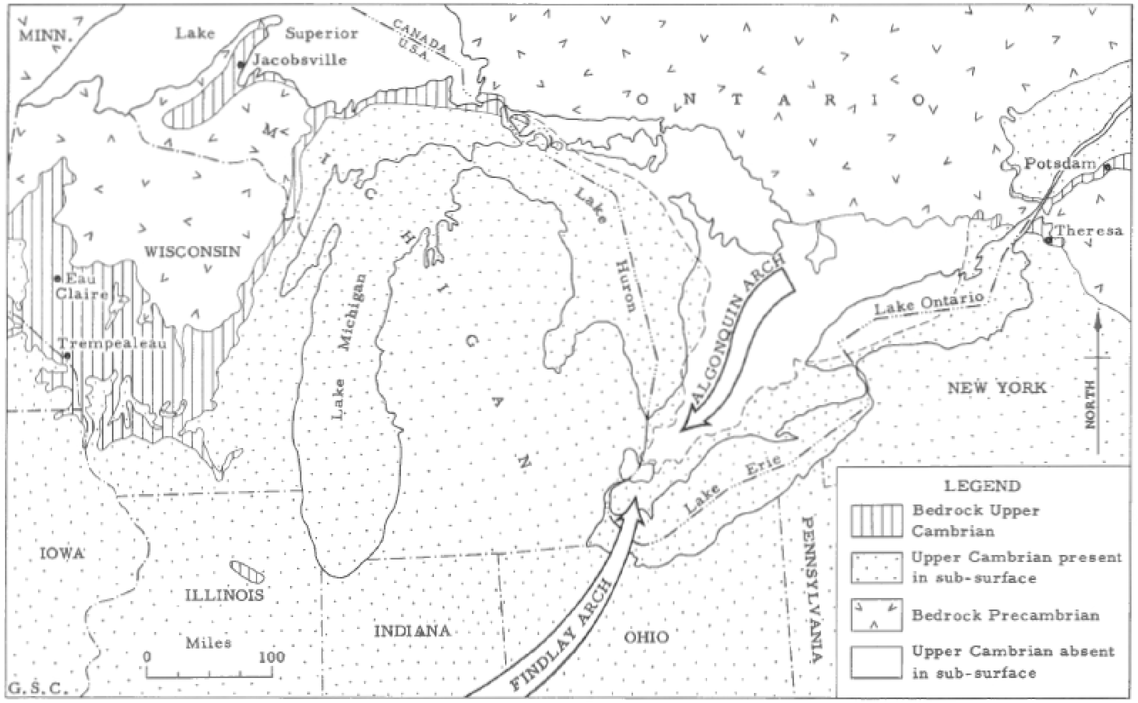


Figure 1 from Sanford & Quillian (1959) illustrating Cambrian outcrop locations.

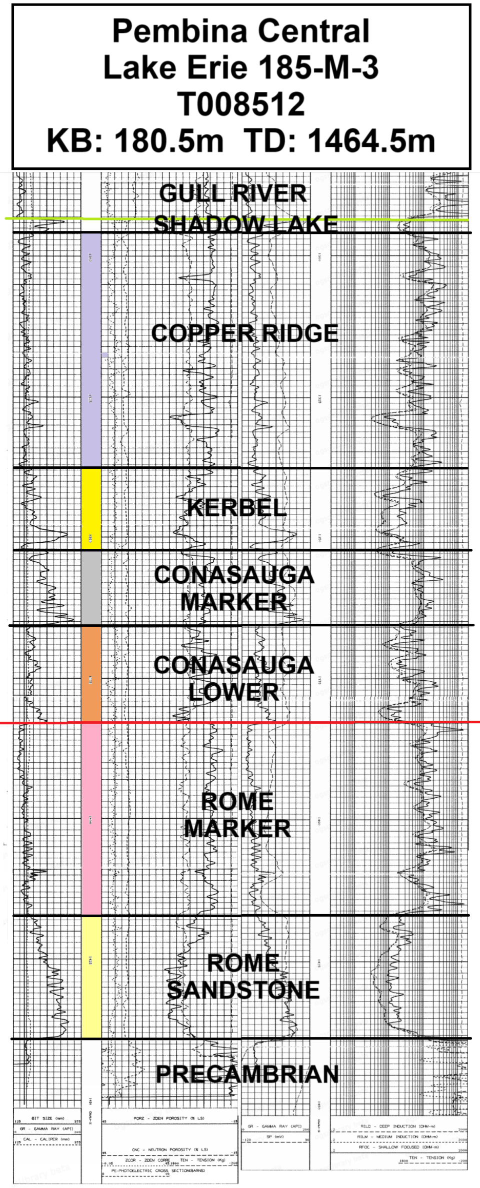
Outcrop photo Nepean Fm sandstones, Southeastern Ontario

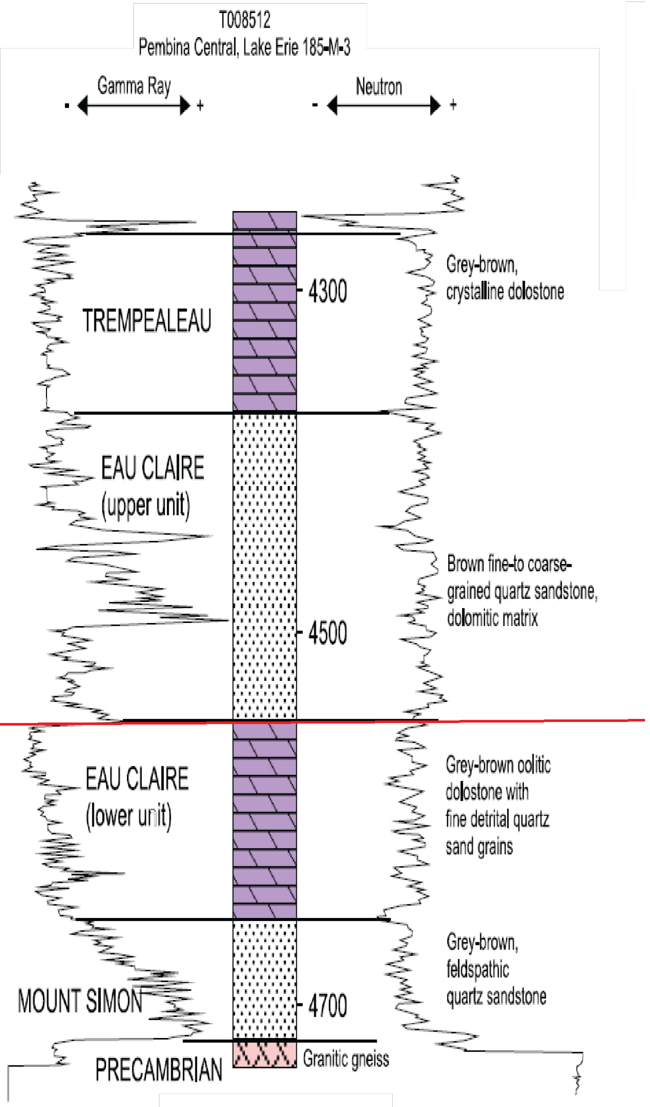
Cambrian Sandstone

Centre Block and the Peace Tower of the Canadian Parliament Buildings in Ottawa is faced with Cambrian Nepean Fm sandstone (Potsdam Group), quarried just west of Ottawa.

Cambrian Nomenclature

- Two log sections compare (on right) Armstong and Carter (2010) type well from a central Lake Erie. They used the same formation names by Trevail (1990).
- Log section on the left from the same well in central Lake Erie using formation names used in current OGS Project SO-22-004. Formation names are taken in part from Ohio subsurface work by Janssens (1973).
- Both log sections are set on same datum (red) the top of the dolostone marker an excellent Cambrian geophysical log marker.

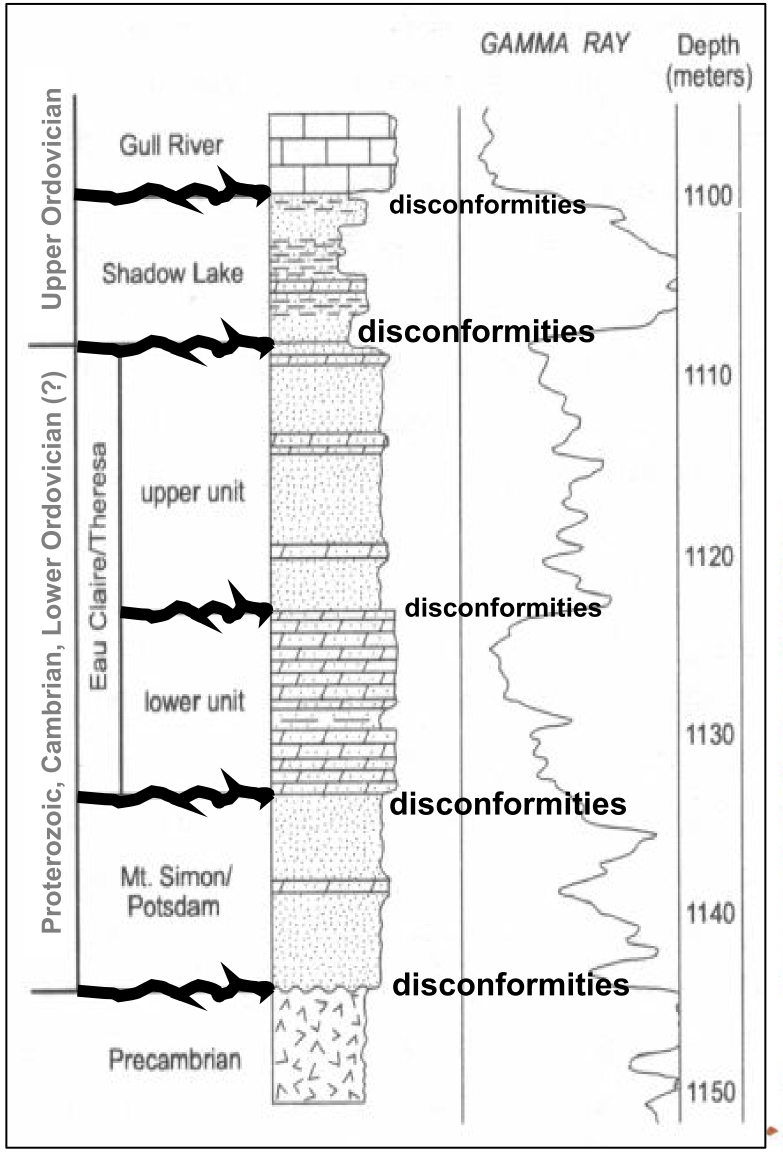




Armstrong & Carter (2010)
OGS Special Volume 7

CO_2 Sequestration - SW Ontario

- Cumulative production as of 2019 was 1.36 TCF natural gas and >93.46 MMbbls of oil from 170 oil pools and 233 gas pools in Paleozoic strata of southern Ontario since 1858.
- No discoveries in other sedimentary basins (i.e., JBL, HBL).
- Currently no injection of CO_2 for enhanced oil production in Ontario.
- No studies on potential for long-term storage of CO_2 in oil and gas reservoirs in Ontario.
- Most significant geologic challenges to overcome, include: 1) abandoned/unplugged Legacy wells; 2) small & under pressured pools; 3) generally insufficient thickness of Paleozoic strata in basins; and 4) generally poor formational fluid temperature and pressure data (e.g., Lake Erie well **33˚C** at 1050m).
- Critical Depth & Temperature requirements: only basal strata are at critical depths >865m; siliciclastics with carbonate cements good potential, silica cements poor potential; Shafeen et al. 2004 suggested saline fluids of Mt. Simon Fm quartz sandstones have greatest potential for CO_2-Sequestration. **NEED** more **detailed Stratigraphic (Fm-rank picks), Sedimentologic, Petrographic-Diagenetic, SEM studies, and temperature, pressure test data** to assess/delineate most promising areas.

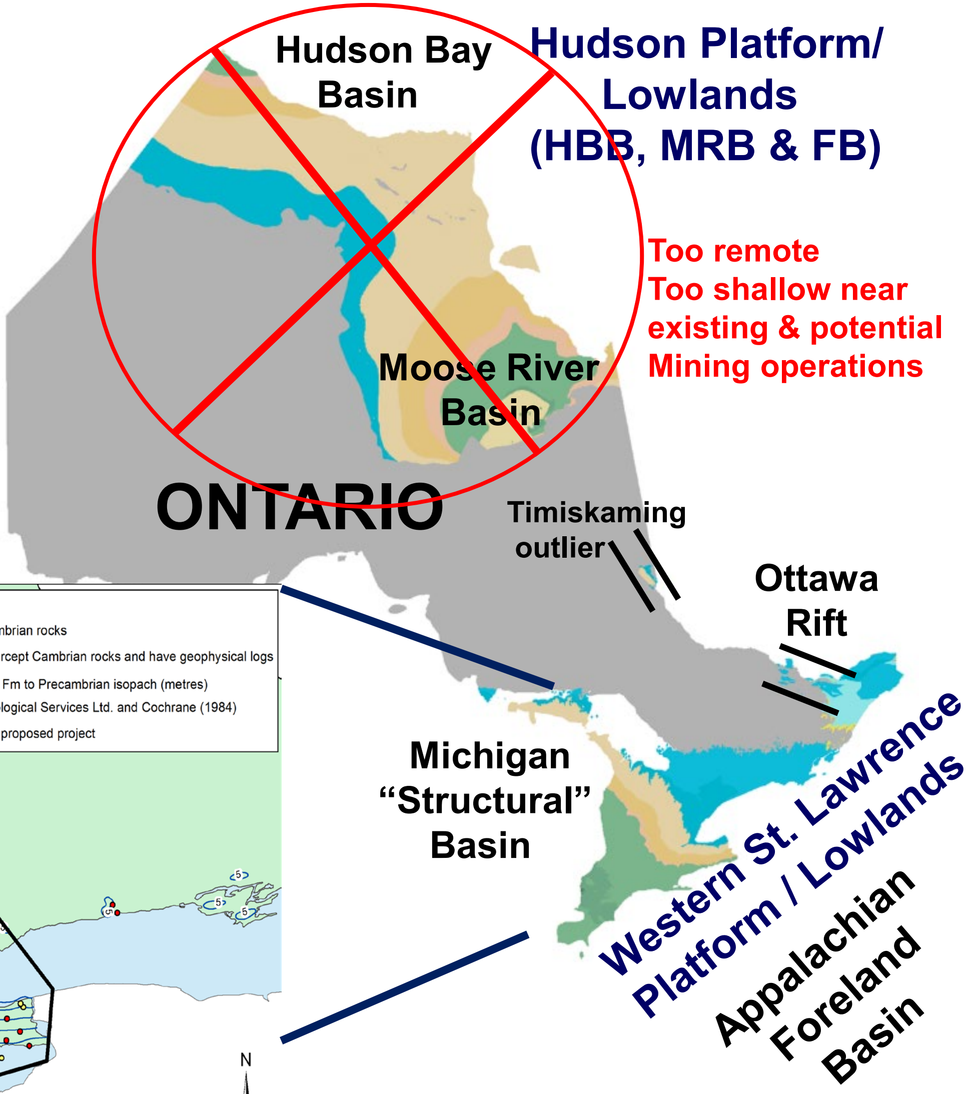


(modified from Trevail 1990)

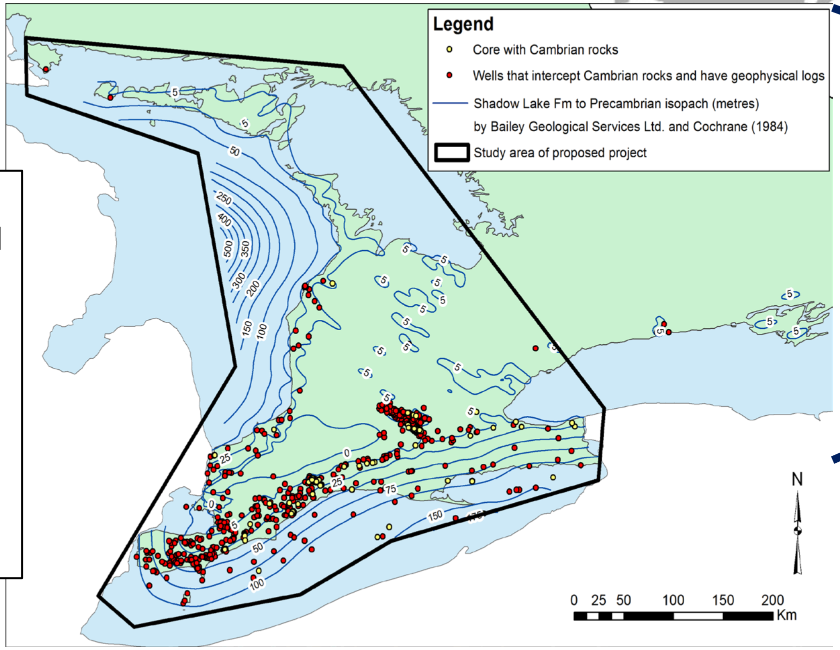
CO_2 Sequestration - Ontario

- Although Paleozoic sedimentary rock strata are up to 1400m thick in parts of SW Ontario, it is generally <800m thick in vicinity of highest CO_2-emitting industries.

- Currently, there is insufficient geological data on basal Cambrian-Lower Ordovician strata, including porosity-permeability & formational fluid chemistry, and pressure & temp data to assess the potential for CCS.

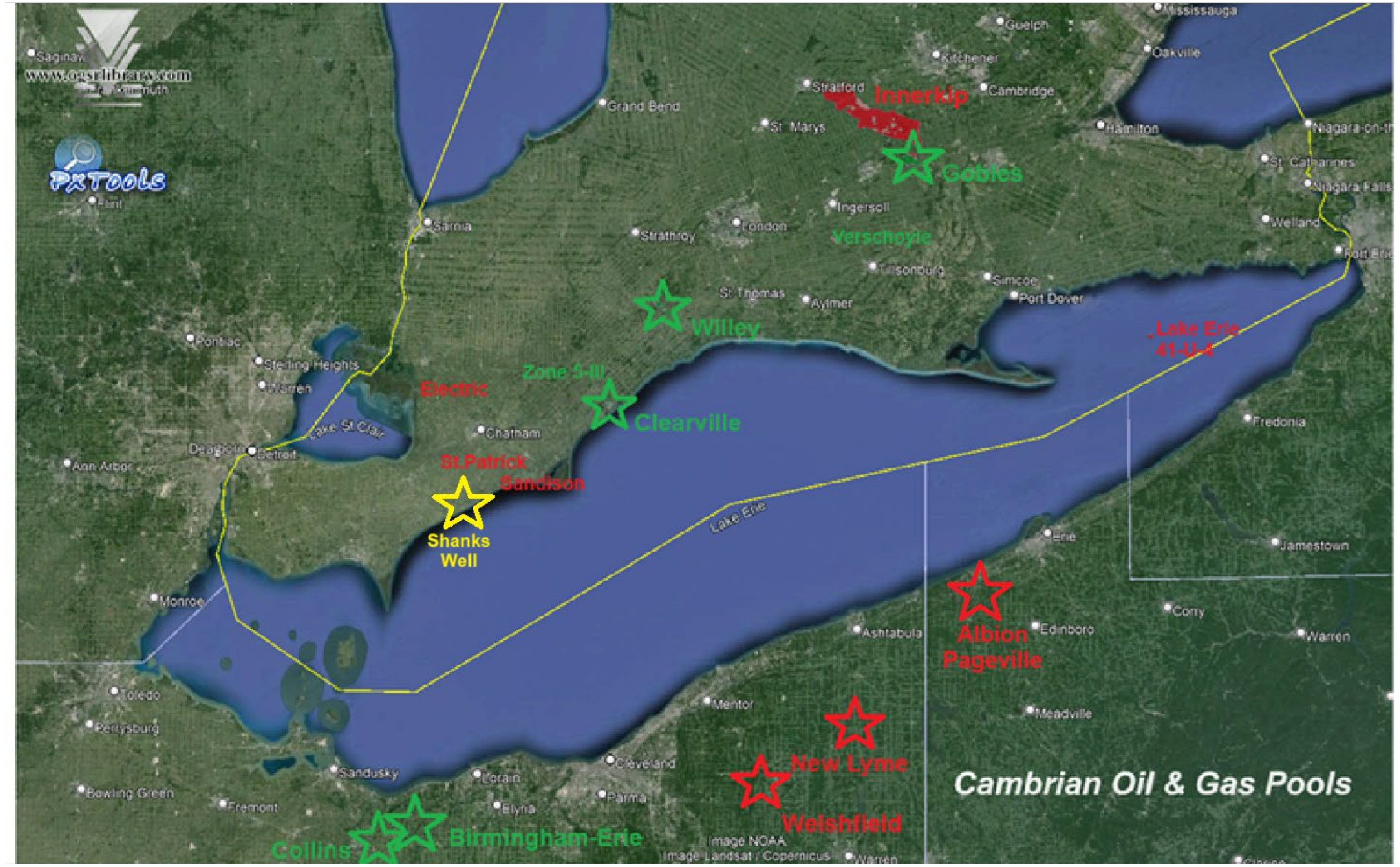


- >20 mostly small, but prolific hydrocarbon reservoirs in basal strata – indicating porous and permeable zones.
- 1230 wells intersect top of Cambrian strata, 740 wells record top of Precambrian; 729 wells have geophysical logs, and 131 wells have cores of these "basal units".



Oil & Gas Production in southwestern Ontario, Ohio & Pennsylvania

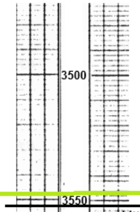
- First oil and gas production in southwestern Ontario from the Cambrian reservoir was over 100 years ago in 1923 (Shanks Well), Kent County, Romney Township.
- The Cambrian interval saw several oil and gas discoveries in the 1960's.
- Oil and gas at Gobles and Innerkip, Oil at Clearville and Oil at Willey.
- At the same time, several oil and gas discoveries were made to the south in Ohio.
- With this increased activity the well database expanded rapidly with many cores being cut and geophysical logging of most wells.



First Cambrian Oil Production
"Shanks Well" November 1, 1923

"This photo shows No.6 Shanks, the flowing oil well described on this page. As noted in the text, the oil is encountered in the Trenton limestone at a depth of 3,560 feet below the surface."

"Shanks Well"
Southern Ontario Gas No. 6
Romney 2-188-TRW
F000667



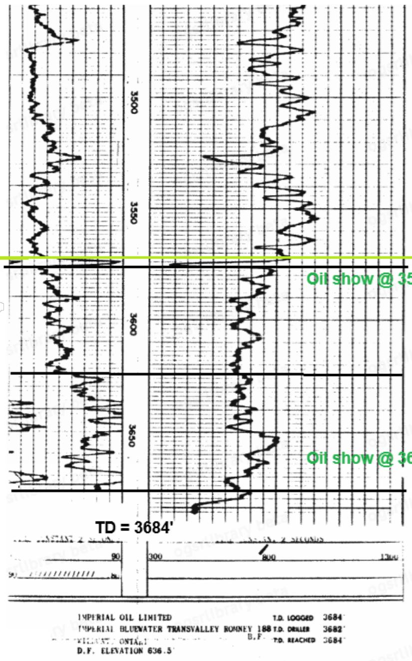
TD = 3560'
Gas & Oil Show @ 3560'
estimate @ 150 bopd

W. H. Kiser (CT)
November 1, 1923

Oil production at least 6000 bbls
Zone abandoned in October 1925
due to sand trouble

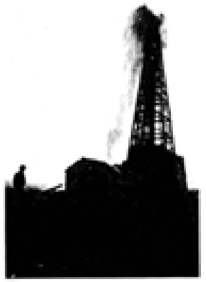
July 27,1925-October 8, 1925
Well shot 3535-3560' (Cambrian)
with 225 lbs 60% dynamite
no significant oil inflow
plugged back for Guelph/Salina gas

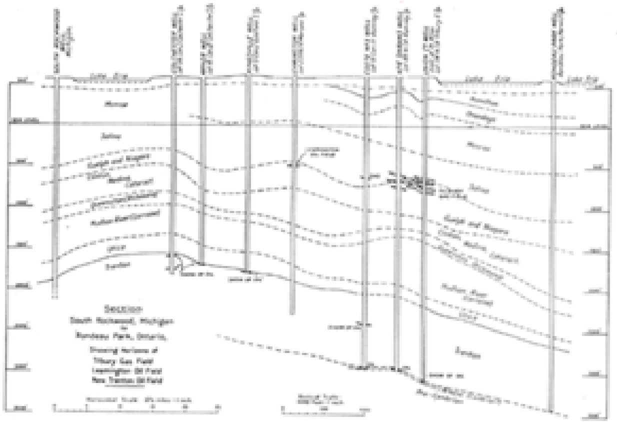
Imperial et al # 728
Romney 1-188-TRW
T000181

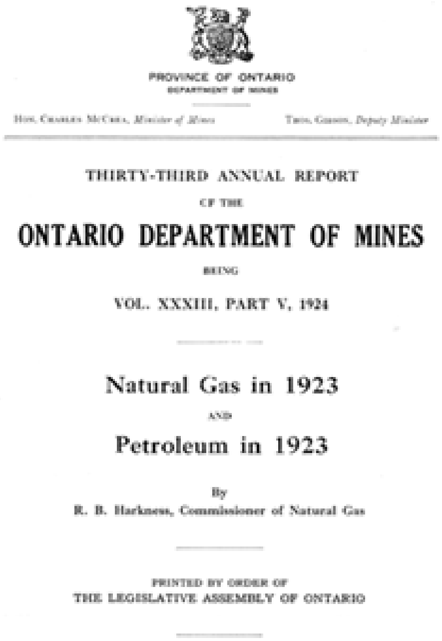


Meier & Shaw (CT)
March 21, 1960

Trenton top @ 2712'	Trenton top @ 2731'
Trenton to TD = 848'	Trenton to Shadow Lake = 842'






PROVINCE OF ONTARIO
DEPARTMENT OF MINES

THIRTY-THIRD ANNUAL REPORT
OF THE
ONTARIO DEPARTMENT OF MINES
BEING
VOL. XXXIII, PART V, 1924

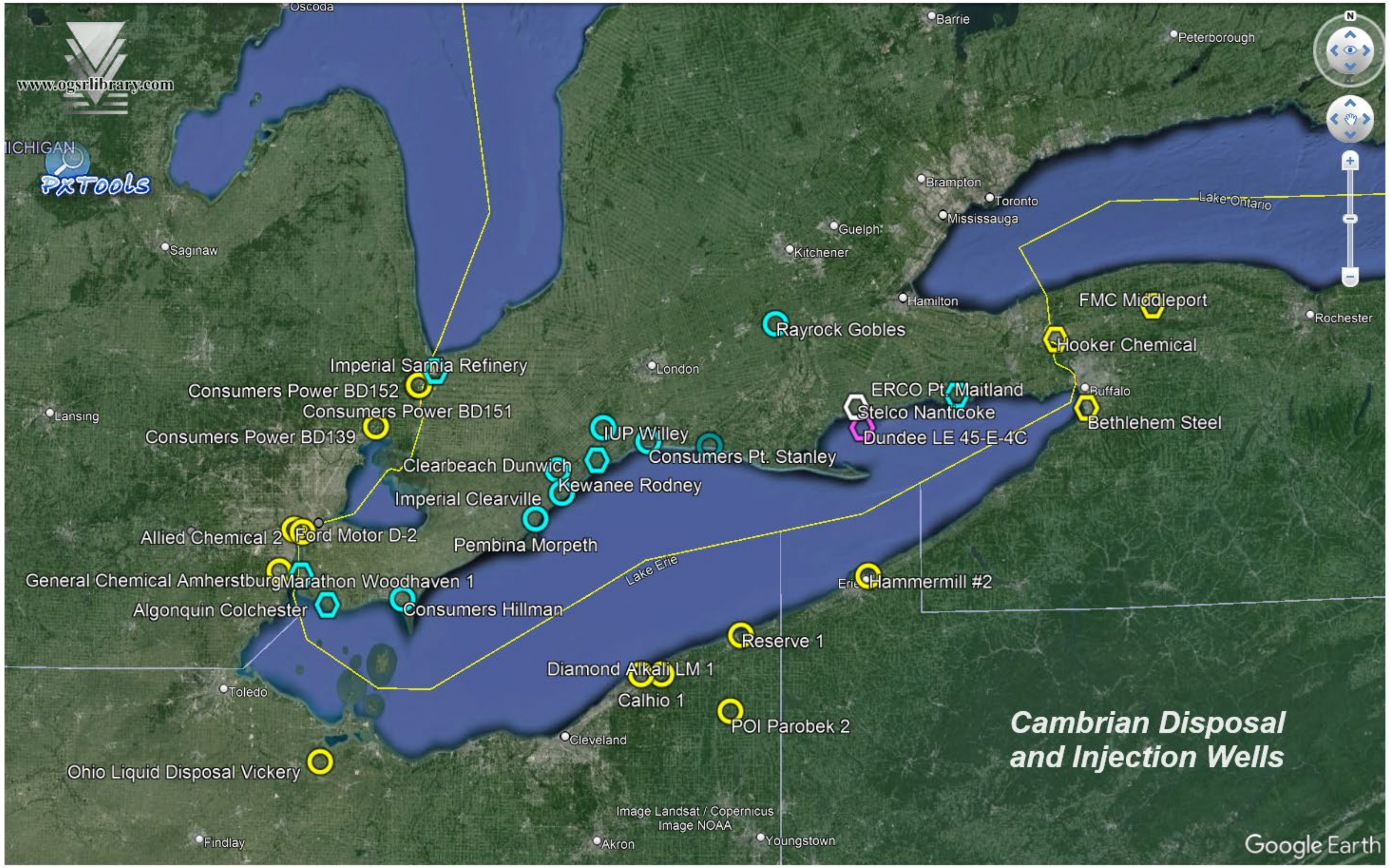
Natural Gas in 1923
AND
Petroleum in 1923

By
R. B. Harkness, Commissioner of Natural Gas

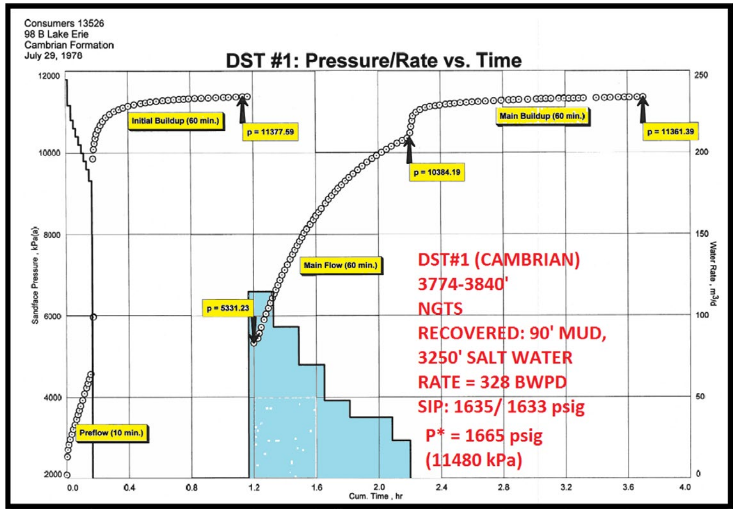
PRINTED BY ORDER OF
THE LEGISLATIVE ASSEMBLY OF ONTARIO

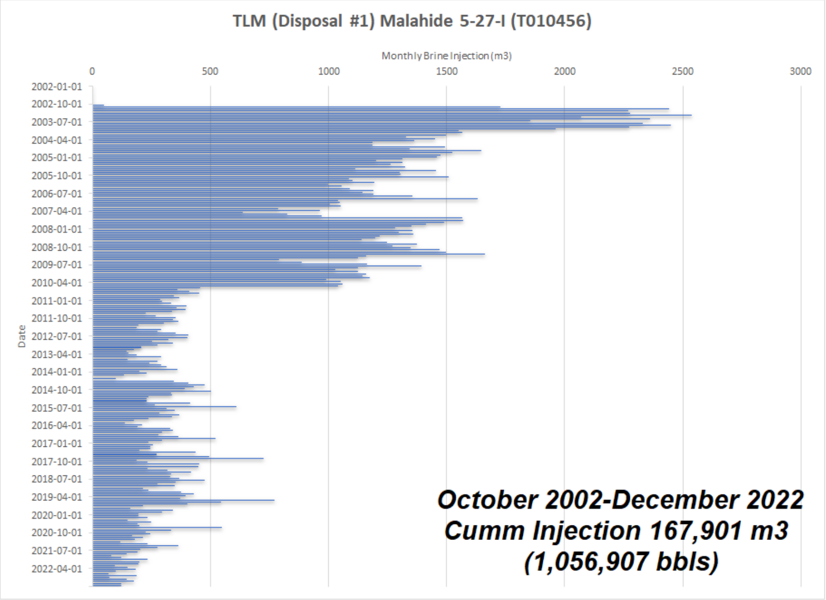
Disposal and Injection wells in southwestern Ontario, New York, PA., Ohio and Michigan

- The 1960-1970's era also saw the Cambrian reservoir being evaluated and used for disposal of brine and chemical waste.
- Cambrian oil producers also began injecting water into the reservoirs at Clearville, Gobles and Willey to enhance oil recovery.



Cambrian Disposal Well Lakeview (Port Burwell)

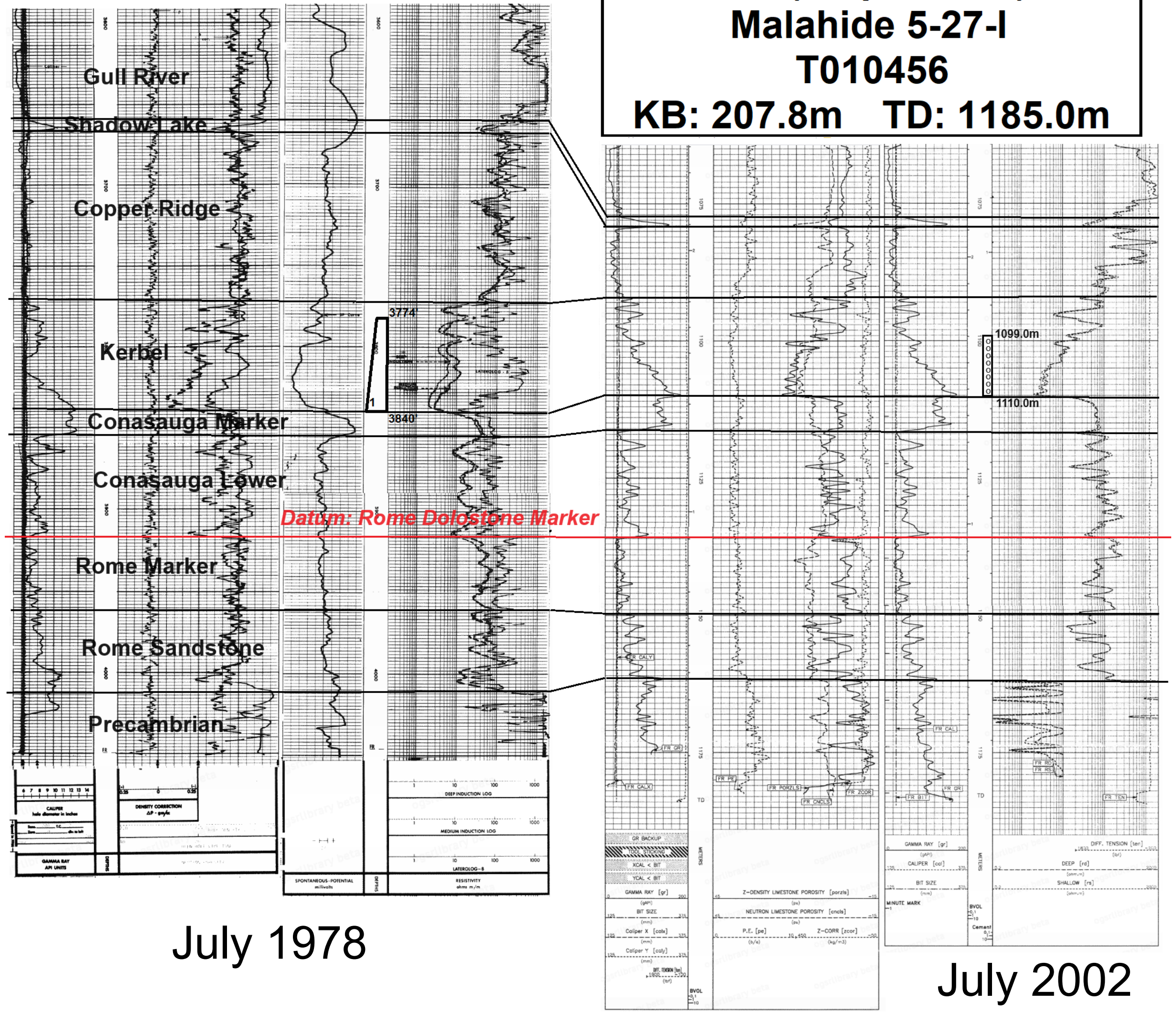




Consumers' 13526A
Lake Erie 98-B-4
T004749
KB: 187.8m TD: 1234.7m

15 km

TLM (Disposal #1)
Malahide 5-27-I
T010456
KB: 207.8m TD: 1185.0m

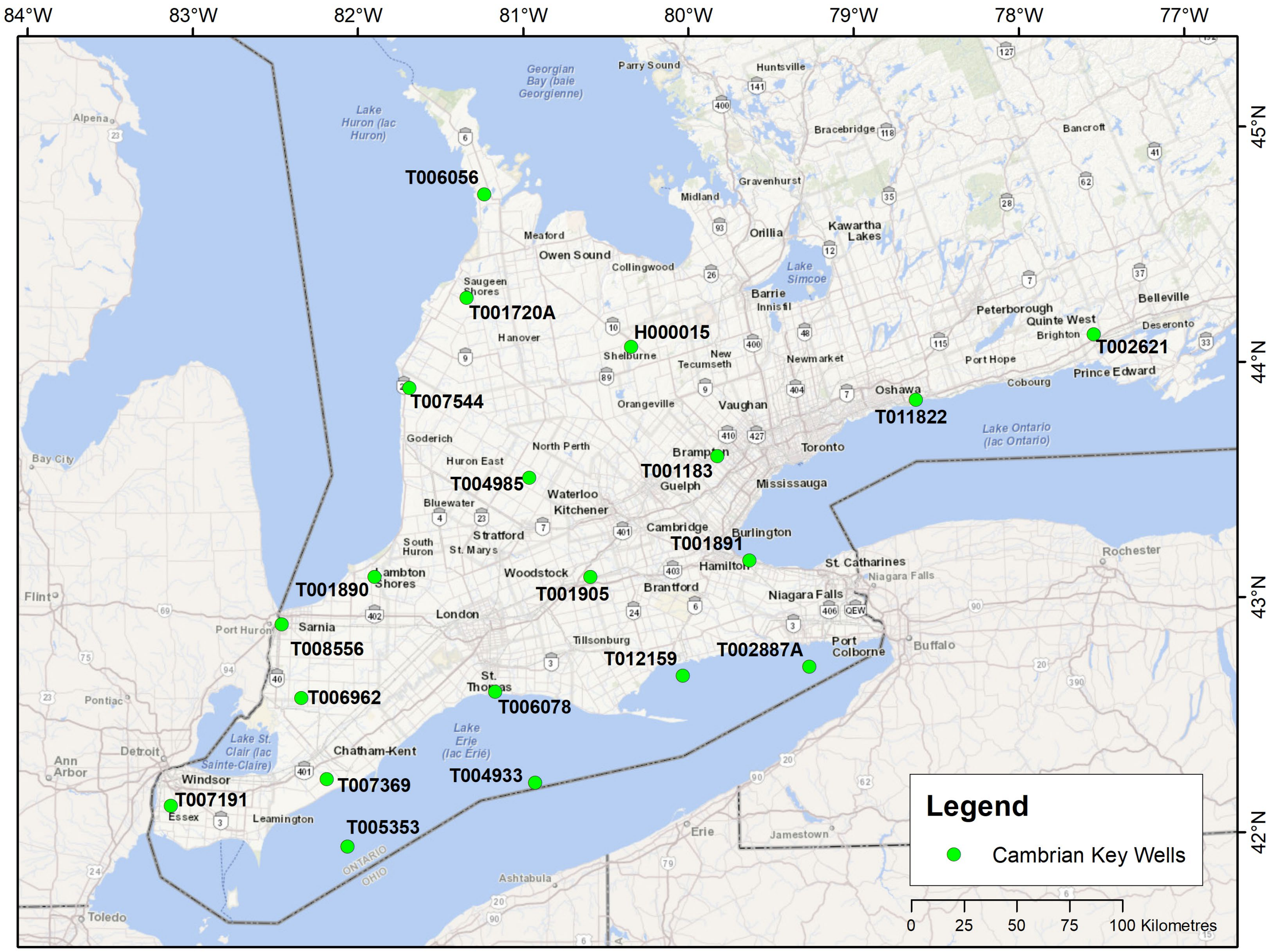


July 1978

July 2002

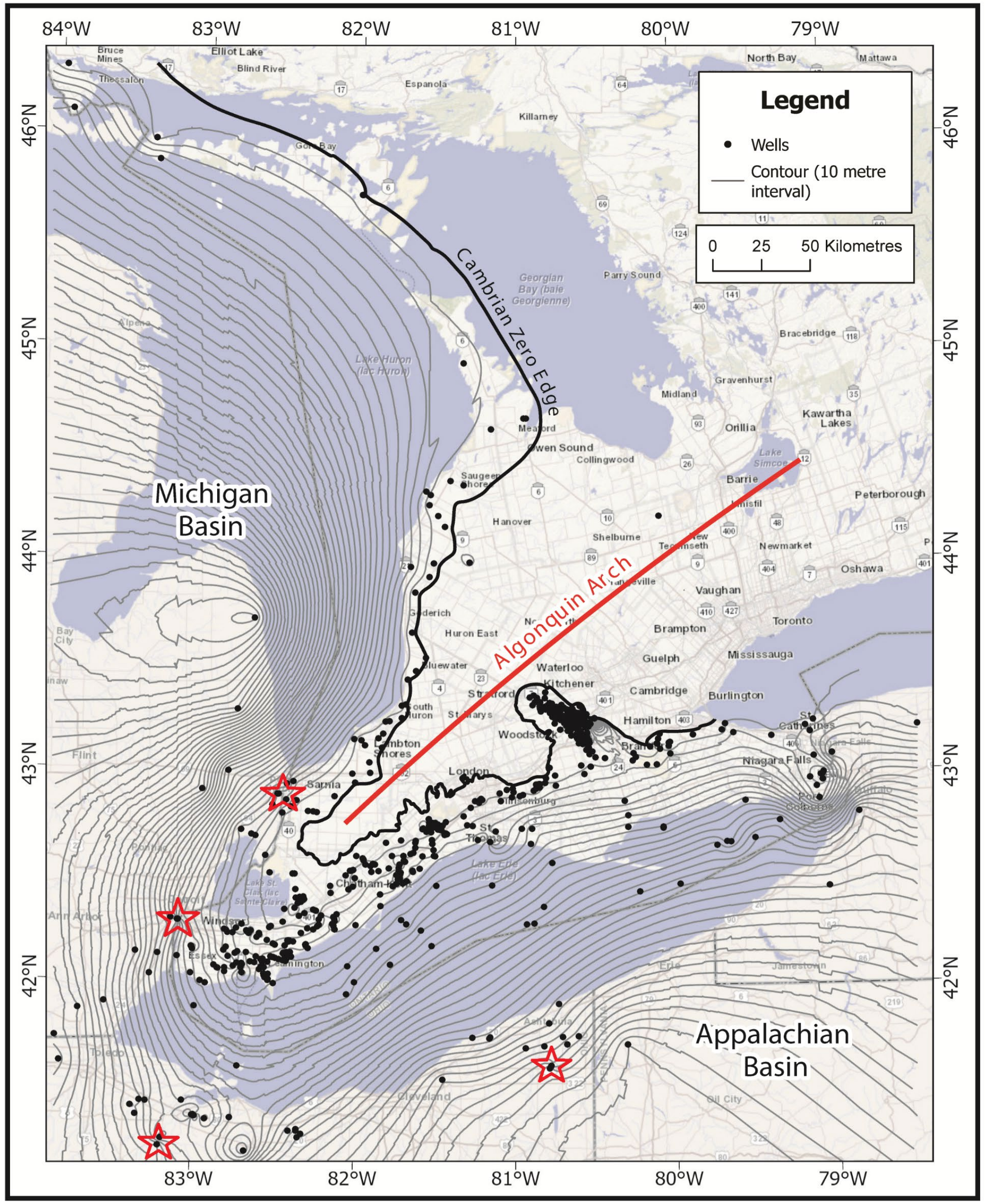
Phase 1 – Cambrian Subsurface study: 20 Key Wells

- The increased Cambrian database in Ontario since 1959 has allowed for the selection of 20 key wells for Phase 1 of the project.
- These wells all have geophysical logs, drill cuttings and many have drill core.
- The core and drill cuttings were logged for each well and the staff at the OGSR Library photographed all the core and drill cuttings.
- These wells will serve as fenceposts to expand correlation outward to the remaining wells.



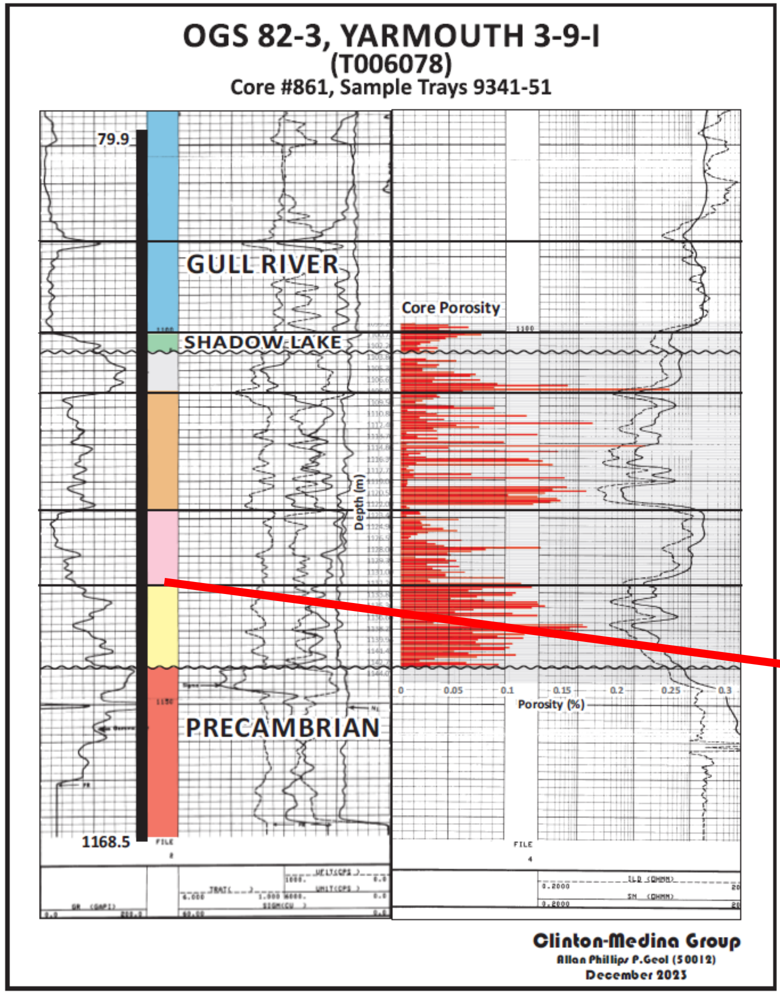
Phase 2 Cambrian Subsurface Mapping : Database Expanded

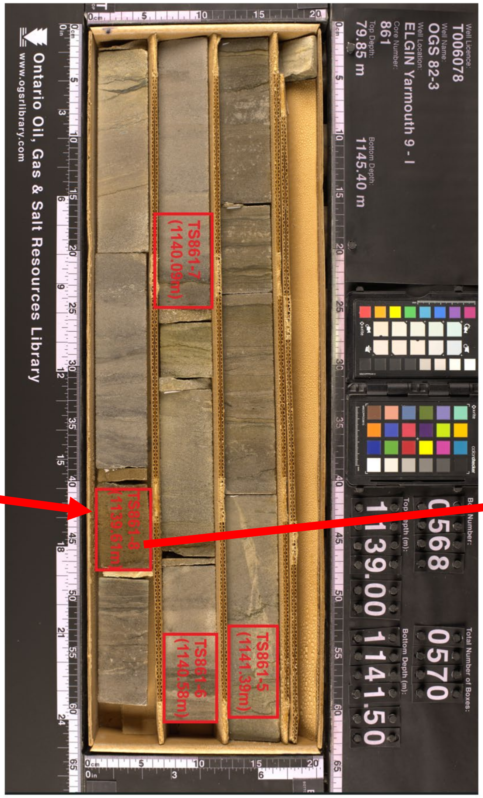
- As part of Phase 2 the database was expanded to look at wells in the states bordering Ontario.
- Well data from New York, Pennsylvania, Ohio and Michigan was incorporated into the study.
- Visits to the Michigan Geological Repository for Research & Education in Kalamazoo, Michigan and H.R. Collins Laboratory & Geological Sample Repository in Columbus, Ohio expanded Cambrian knowledge base.
- Selecting wells with near complete core over the Cambrian interval allowed for the comparison and correlation to the Ontario wells.
- The number of key wells was expanded to 26 to include additional core, sample and geophysical log data in areas that were showing data quality issues and more complex stratigraphy.

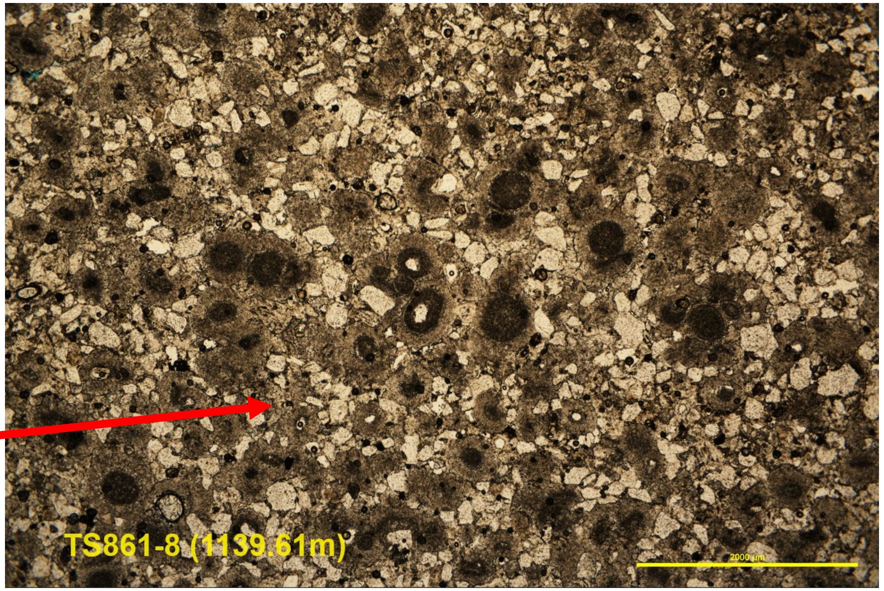


epex 2025
OPI 62nd Conference and Trade Show

Phase 2 also included for the sampling and preparation of 210 thin sections to advance the understanding of this complex reservoir.





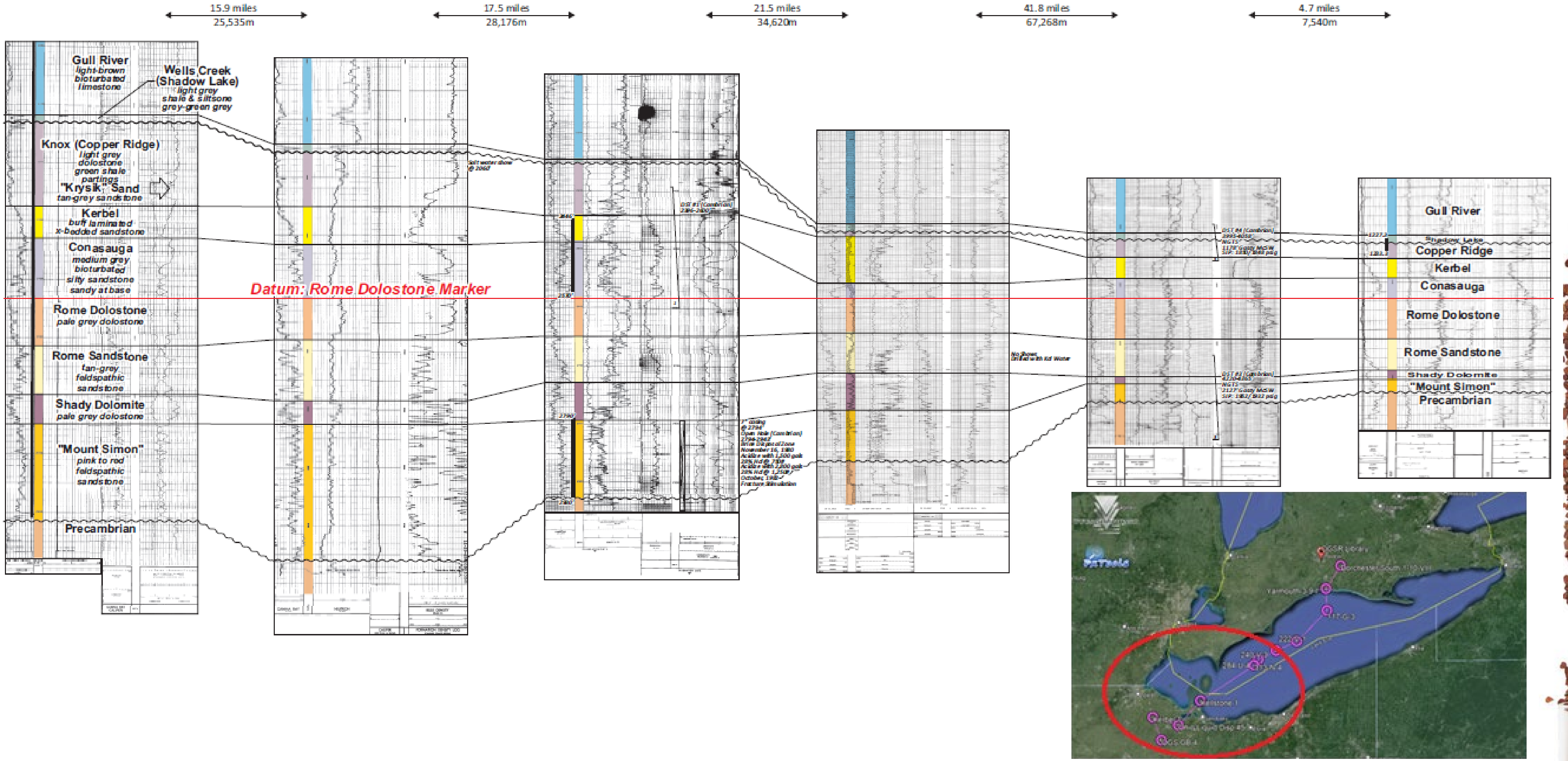


Ohio to Ontario Cross-Section

Correlation of Cambrian in Ohio north into southwestern Ontario

epex 2025
OPI 62nd Conference and Trade Show

OHIO GEOLOGICAL SURVEY GB-4	RUSSELL MAGUIRE - KERBEL #1	OHIO LIQUID DISPOSAL #5	KELLSTONE - KELLSTONE #1	CONSUMERS' 13501	CONSUMERS' 13730
SENECA COUNTY, LIBERTY TWP.	SANDUSKY COUNTY, WOODVILLE TWP.	SANDUSKY COUNTY, RILEY TWP.	ERIC COUNTY, KELLY'S ISLAND	LAKE ERIE 313-N-4	LAKE ERIE 284-U-4
API # 34147608400000	API # 34143201470000	API # 34143202370000	API # 34043201710000	T004772	T005353
STRATAGRAPHIC TEST	DRY HOLE	DISPOSAL WELL	OIL & GAS SHOW -ABANDONED	OIL & GAS SHOW -ABANDONED	OIL & GAS SHOW -ABANDONED
KB: 698' TD: 2870'	KB: 647' TD: 2785'	KB: 618' TD: 2943'	KB: 625' TD: 3436'	KB: 594' TD: 4365'	KB: 181.2m TD: 1328.0m



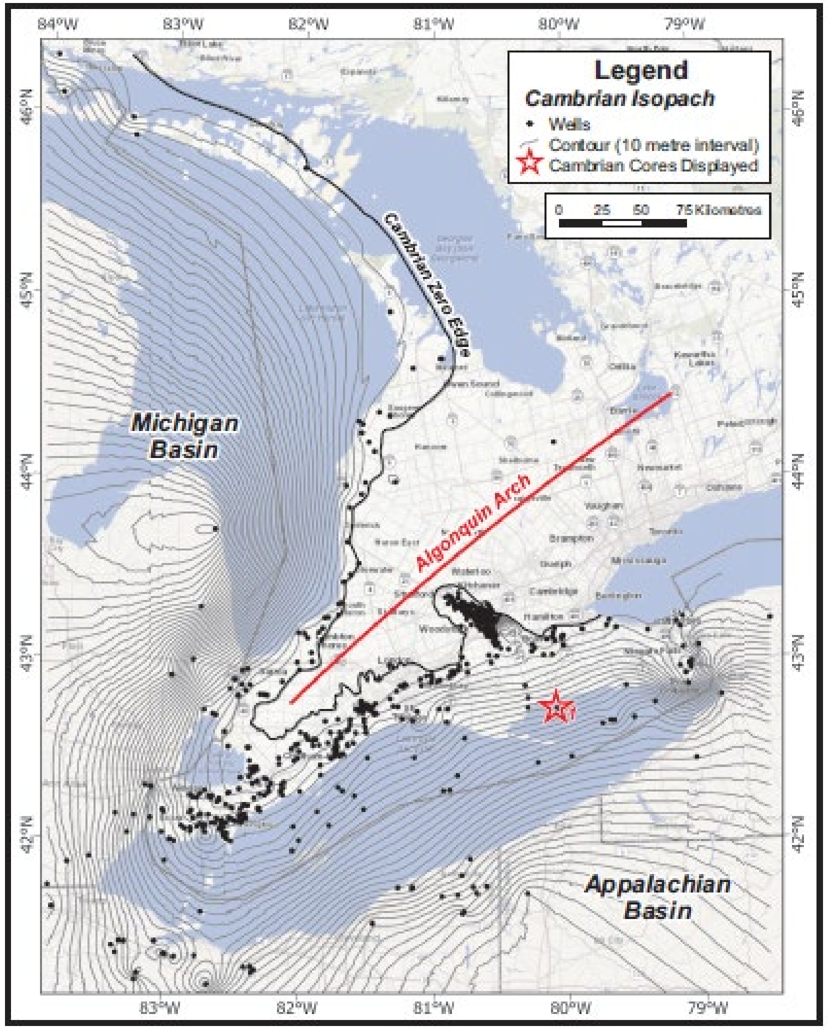
CAMBRIAN CORES ON DISPLAY

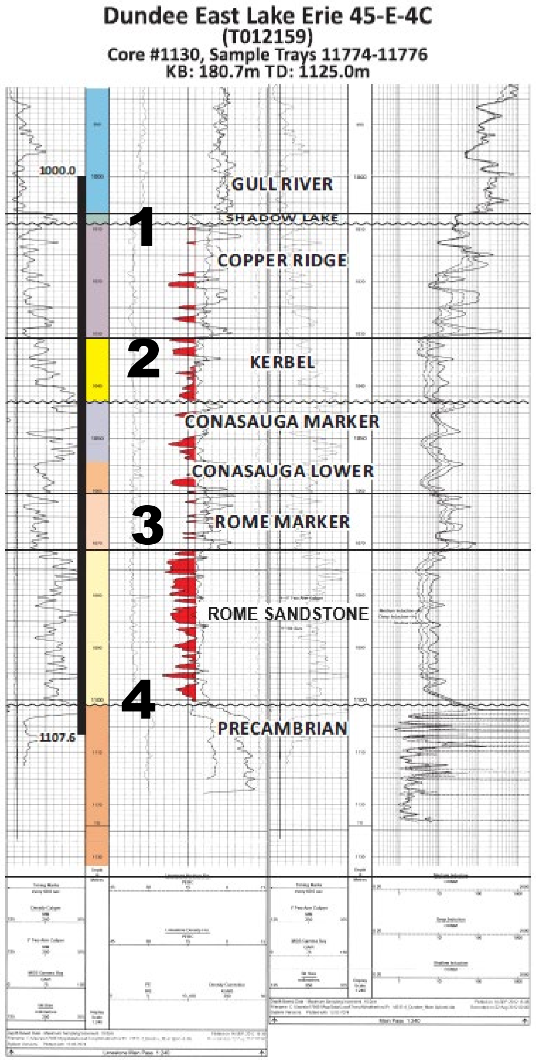
Stratigraphic test drilled in East Lake Erie in 2012 by Dundee Energy

Oil well drilled east of Chatham in 1962 by Imperial Oil

Exploration well drilled in Lake Erie in 1979 by Consumers' Gas

Dundee East Lake Erie 45-E-4C (T012159), Core #1130





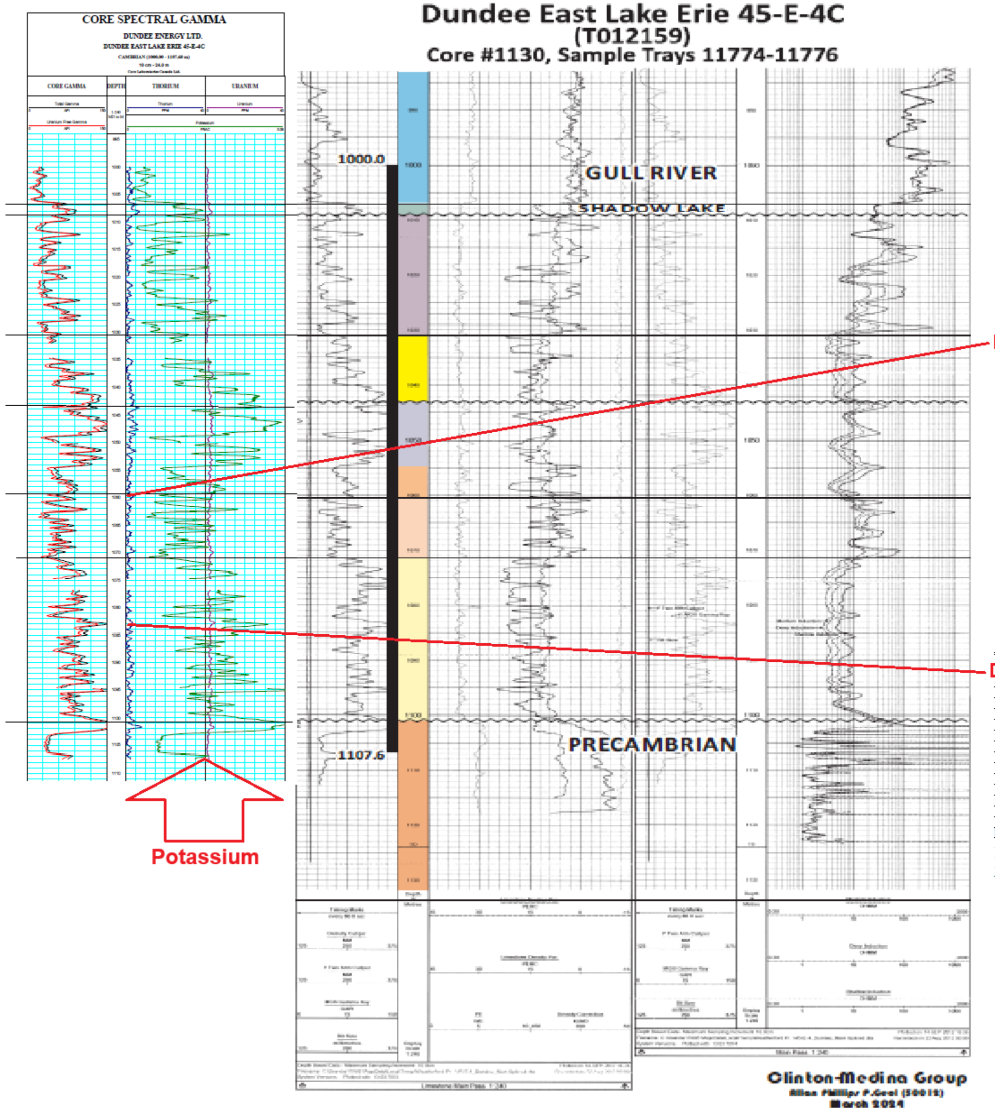
Cored interval 1000.0-1107.6m
104.1m of core recovered.
Selected 4 intervals:

1. Upper Ordovician Gull Fm to top of Cambrian
2. Kerbel Fm Sandstone
3. Rome Fm Dolostone Marker
4. Rome Fm Sandstone-Precambrian

How does K-feldspar content affect the geophysical log Gamma Ray?

- Spectral core gamma run by core labs illustrates how total gamma and potassium content track.
- Two thin sections (one dolostone and one sandstone) indicate how Kfs (potassium feldspar) percentages vary.
- The data can be matched back to core gamma and geophysical log gamma to illustrate how increase in Kfs% drives up GR.
- This is an important take away when looking at Cambrian succession in southwestern Ontario.
- Sandstones will have high GR counts.
- Dolostones low GR counts.

Note: This example demonstrates how the GR tool can be an important indicator of lithology.



TS1130-59 @ 1059.95m
Rome Dolostone

Class	Feature	% Total Featur	Notes
Dol	476	88.48	
Kfs	33	6.13	
Cal	4	0.74	
Qz	12	2.23	
Plag	0	0.00	
Py	0	0.00	Observed in BSE
Rt	0	0.00	Observed in BSE
Ap	0	0.00	Observed in BSE
Chl	0	0.00	
Phl / Bt	1	0.19	
Zrn	0	0.00	Observed in BSE
Cements?	11	2.04	
Rt Cement	0	0.00	
Barite	0	0.00	
Fe-oxide	0	0.00	Observed in BSE
Ilm	1	0.19	
Totals	538	100.00	

Pore space not classified with modal mineralogy.
* % Total Features = exluding unclassified analyses
minerals listed as 0% total features may be present in trace amounts

TS1130-37 @ 1083.15m
Rome Sandstone

Class	Feature	% Total Featur	Notes
Dol	59	12.27	
Kfs	266	55.30	
Cal	12	2.49	
Qz	109	22.66	
Plag	10	2.08	
Py	0	0.00	Py observed in BSE
Rt	0	0.00	
Ap	1	0.21	
Chl	2	0.42	
Phl / Bt	6	1.25	
Zrn	1	0.21	
Cements?	15	3.12	
Rt Cement	0	0.00	
Barite	0	0.00	
Fe-oxide	0	0.00	
Ilm	0	0.00	
Totals	481	100.01	

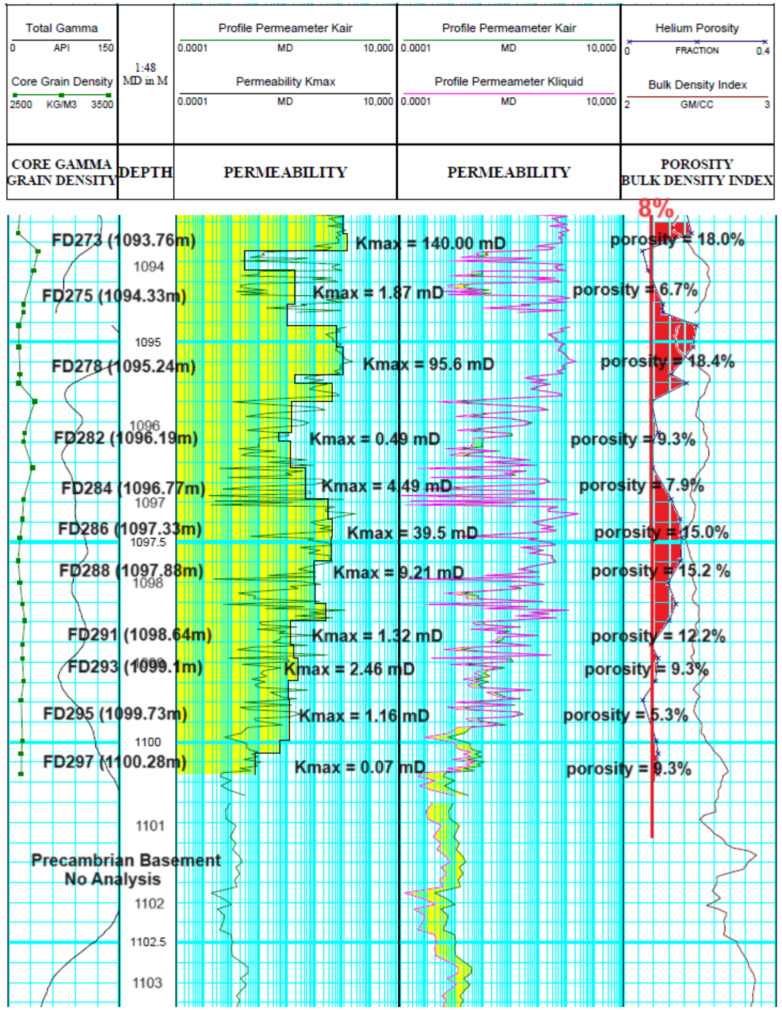
Pore space not classified with modal mineralogy.
* % Total Features = exluding unclassified analyses
minerals listed as 0% total features may be present in trace amounts

Reservoir Heterogeneity

Full Diameter Core Analysis vs. Profile Permeameter Analysis

297 Full Diameter Analysis
(sample every 33 cm)

3083 Profile Permeameter Points
(sample point every 3.3 cm)



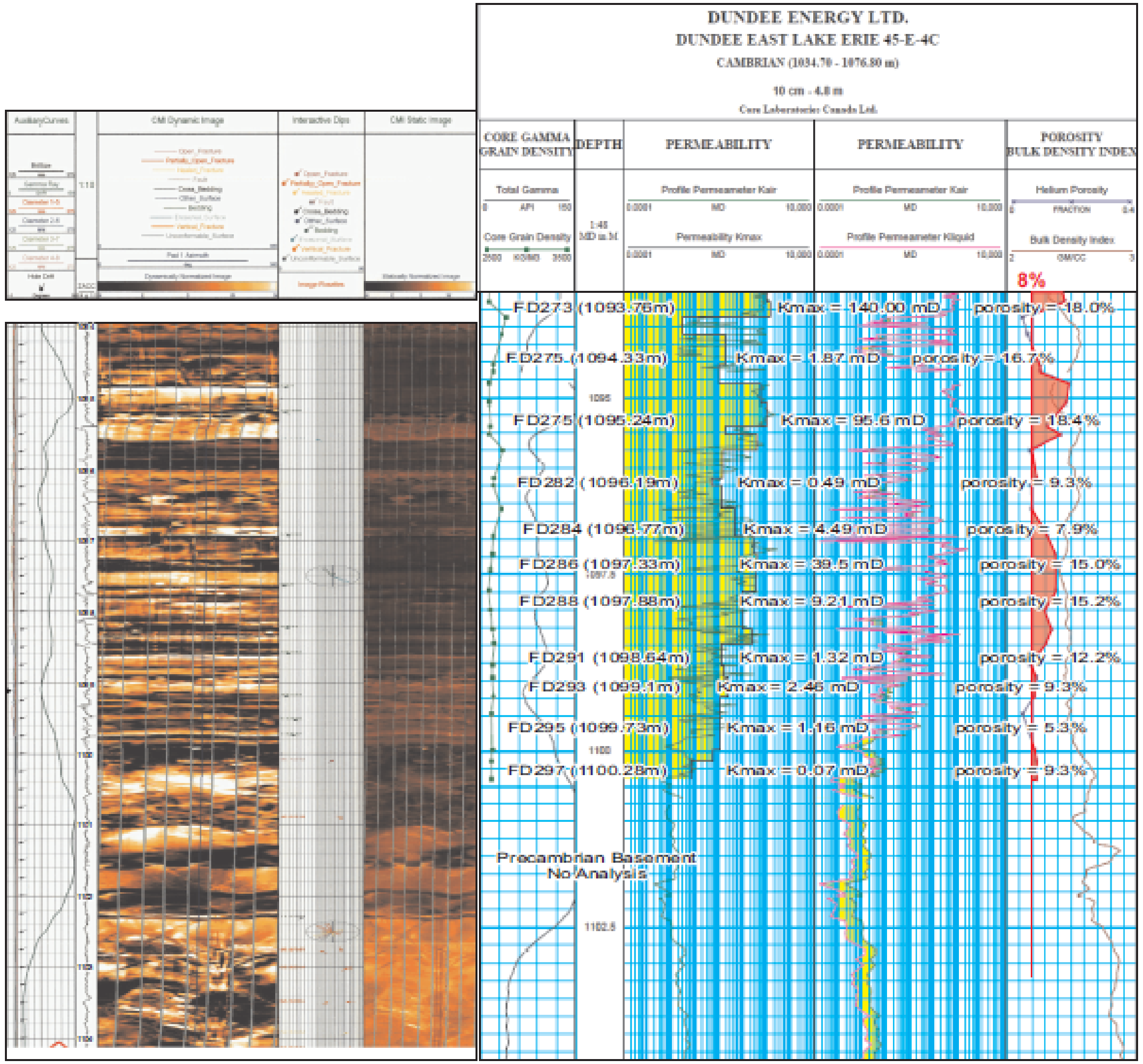
Match Core Data to Image Log Data

Weatherford
Compact Micro-Imager Interpretation Results

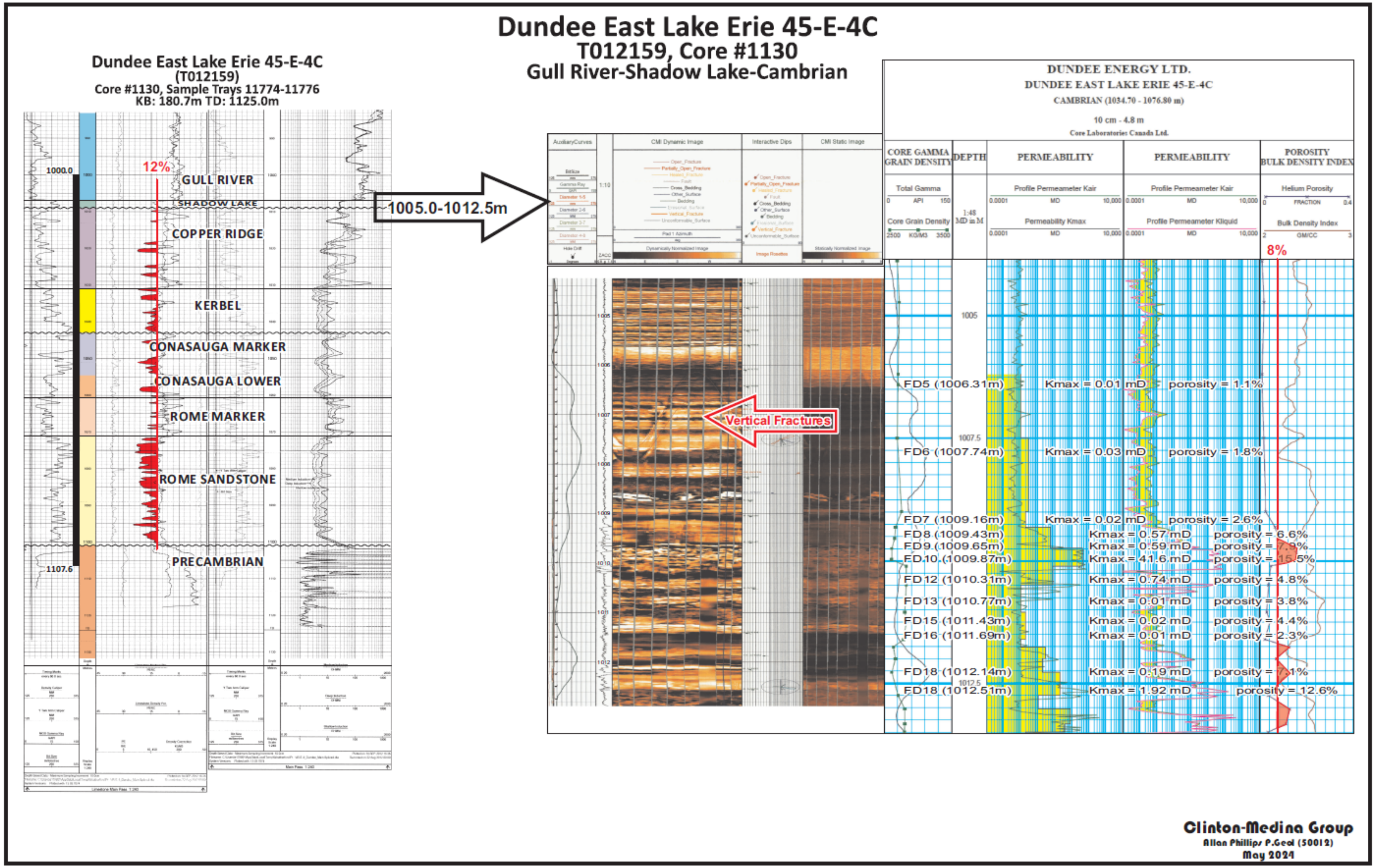
- Resistivity image data (Statically Normalized Image) from the wellbore is matched to the core porosity and permeability data to further understand reservoir heterogeneity in this reservoir.

- Dark (conductive) salt water filled porous and permeable sands contrast with the poorer reservoir orange (resistive) crystalline basement, carbonates and dolomite cemented sandstones resulting in a visual representation of reservoir quality.

Dundee East Lake Erie 45-E-4C
T012159, Core #1130
Basal Sandstone-Precambrian

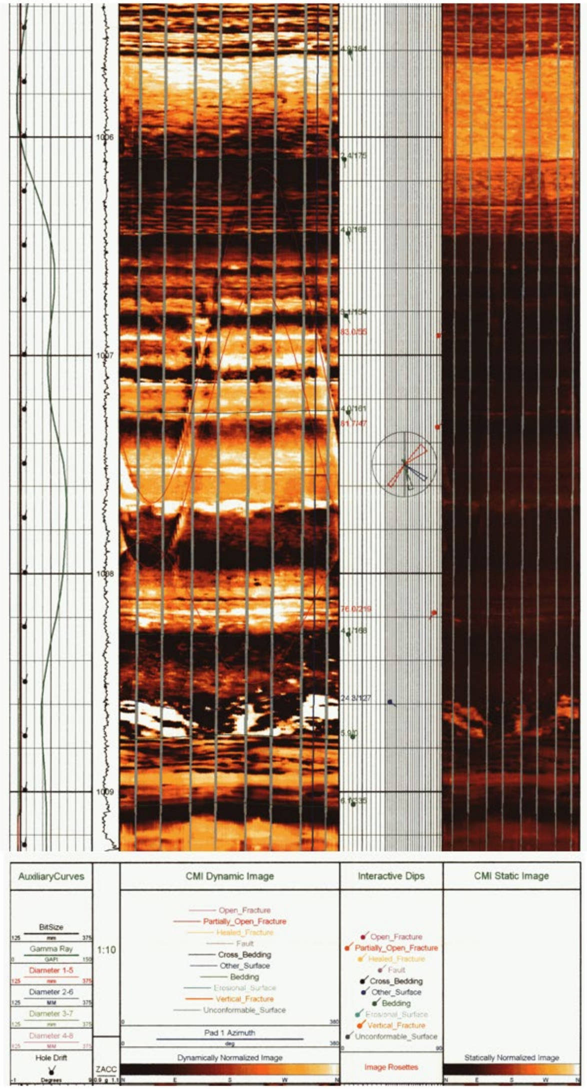


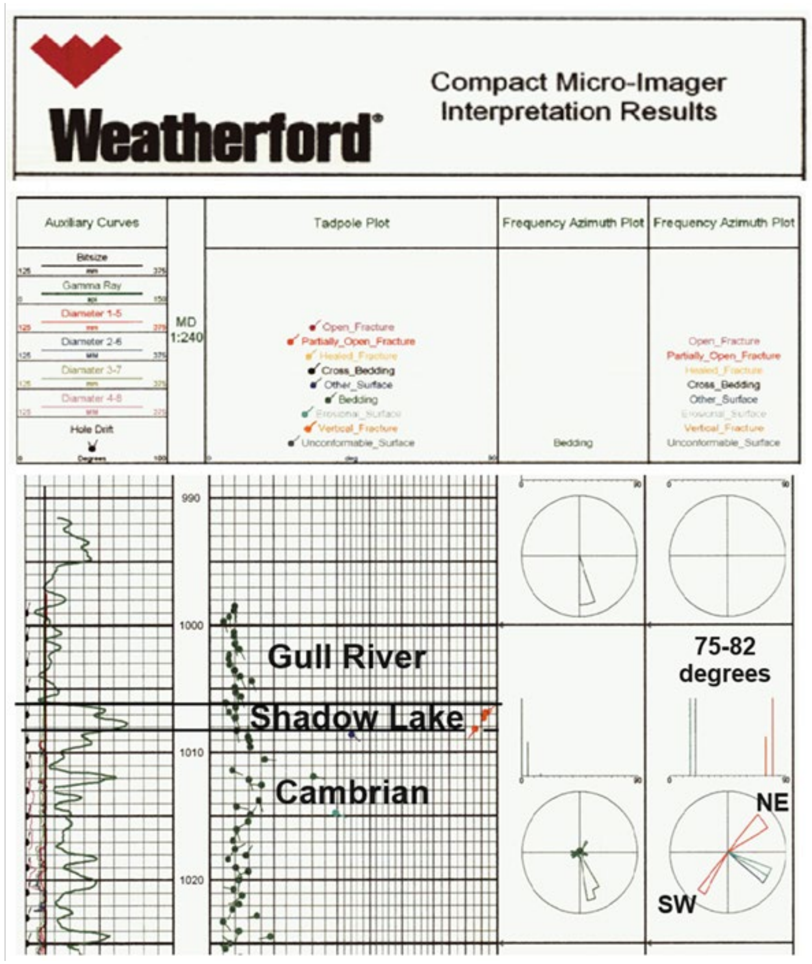
Gull River-Shadow Lake-Cambrian



Shadow Lake Vertical Fracture

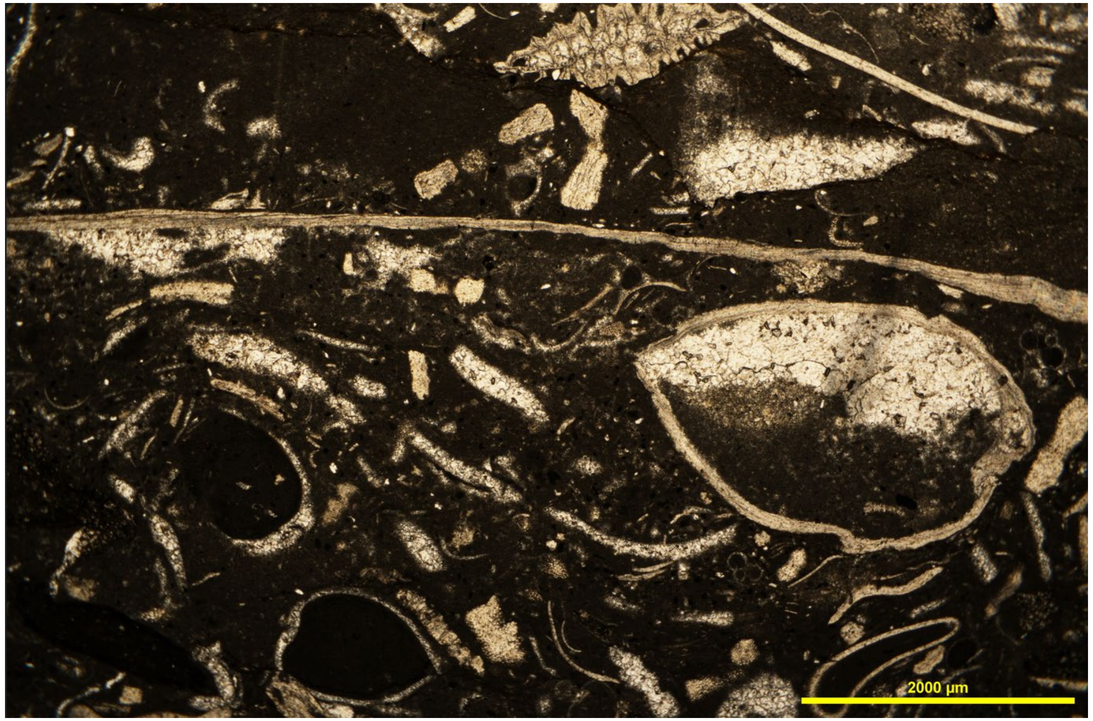
DUNDEE EAST, LAKE ERIE 45-E-4C
T012159, CORE #1130
Shadow Lake @ 1007.3m





high angle 75-82º orientation SW-NE

Gull River Limestone @ 1006.88m

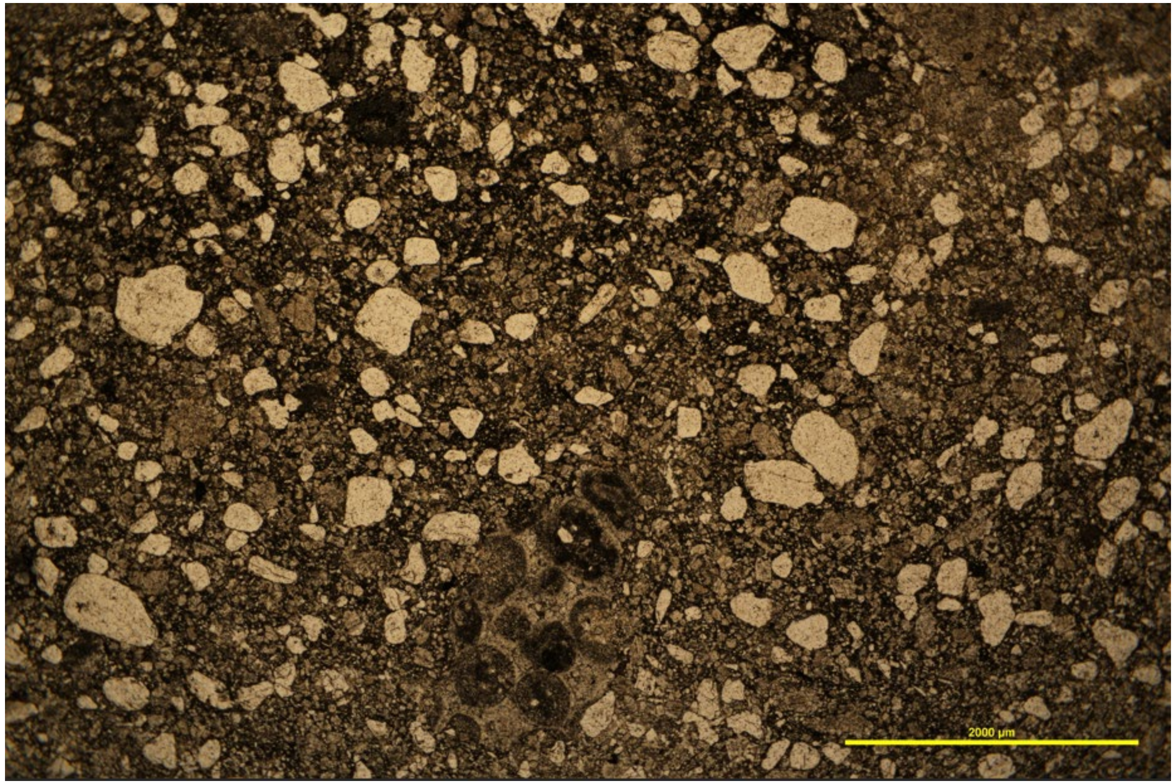


Dundee East Lake Erie 45-E-4C (T012159), Core #1130
Gull River (Cap Rock) @ 1006.88m
FD5 (1006.20-1006.42m)
Porosity = 1.1%, Kmax = 0.01mD
TS1130-90

TS1130-90: Calcareous mudstone (micrite) is generally featureless apart from scattered shell fragments up to 2.5 mm long. Most of the shell fragments were derived from thin-shelled bivalves (also evidence of bryozoans, brachiopods, crinoid plates and ostracods). Note the geopetal fabric in the articulated bivalve shell in bottom right. The bottom of shell is filled with carbonate mud and the remaining upper part of the cavity is filled with sparry calcite cement (indicating the way up).

No porosity is evident in this thin section.

Shadow Lake @ 1009.24m

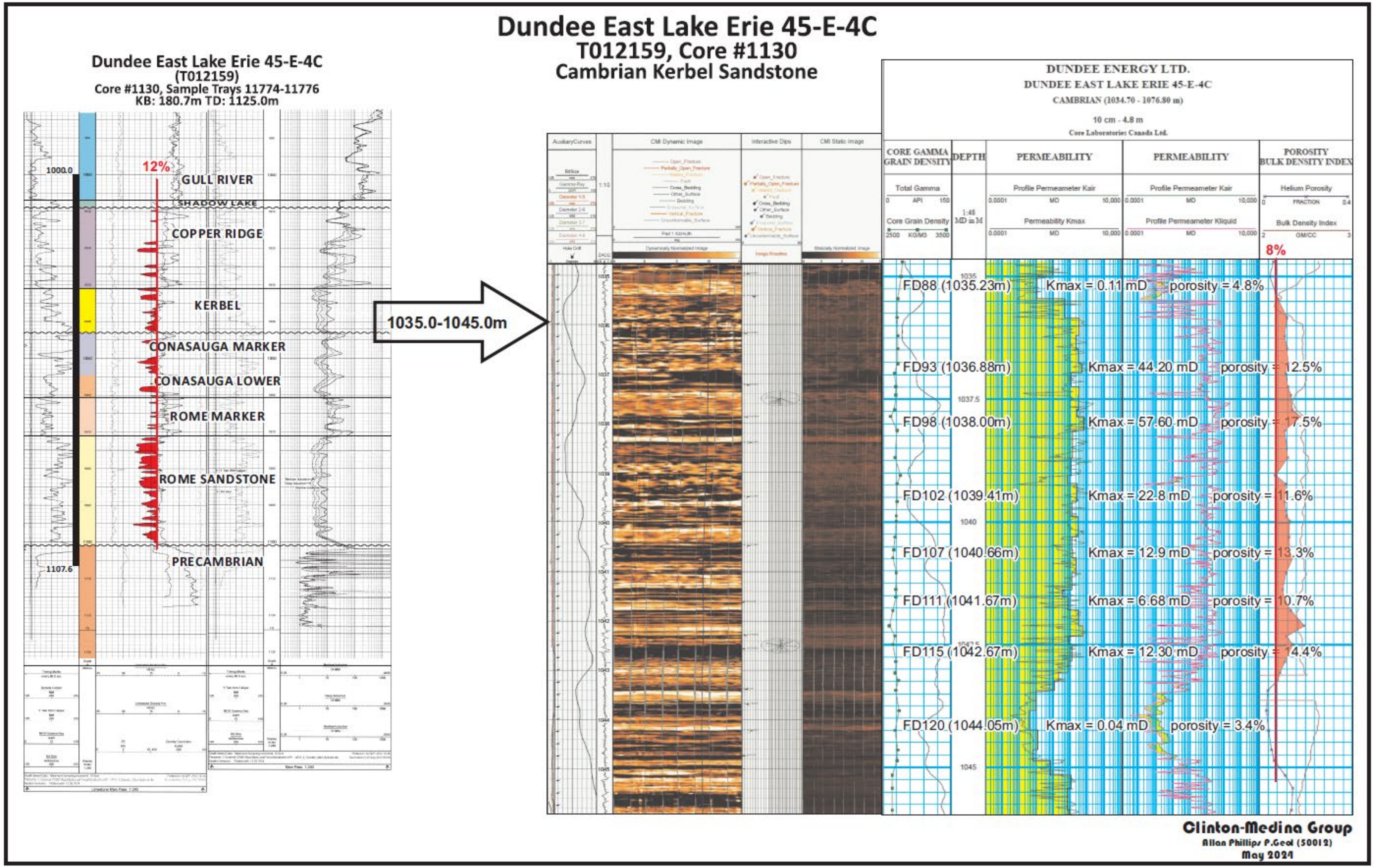


Dundee East Lake Erie 45-E-4C (T012159), Core #1130
Shadow Lake @ 1009.24m
FD7 (1009.00-1009.32m)
Porosity = 2.6%, Kmax = 0.02mD
TS1130-87

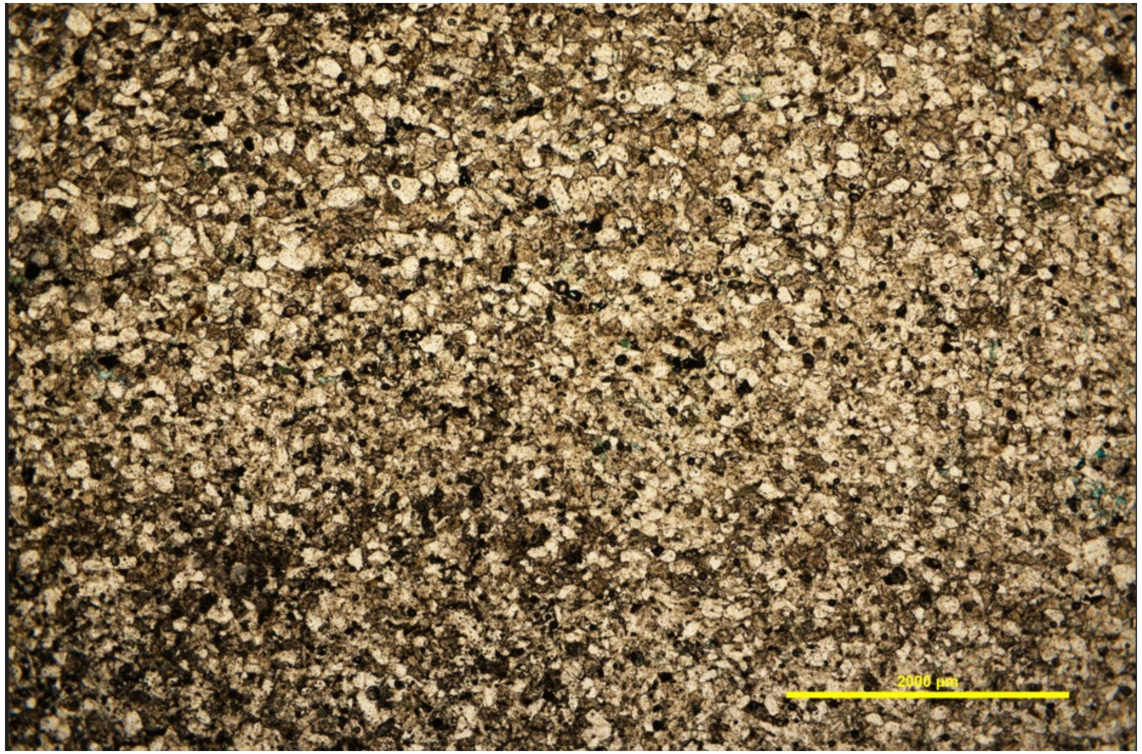
TS1130-87: Sandy dolostone scattered quartz grains in a dolomitic groundmass with isolated patches of calcite cement and minor amounts of disseminated pyrite. The poorly sorted, angular to rounded quartz grains, which are 0.1 to 1 mm long, are irregularly scattered throughout the sample. In general, the smaller grains are angular to subangular whereas the larger grains are subrounded to rounded. A 2mm long lithoclast of oolitic dolostone occupies the bottom middle portion of the image.

Minimal porosity is evident in this thin section.

Cambrian Kerbel Sandstone



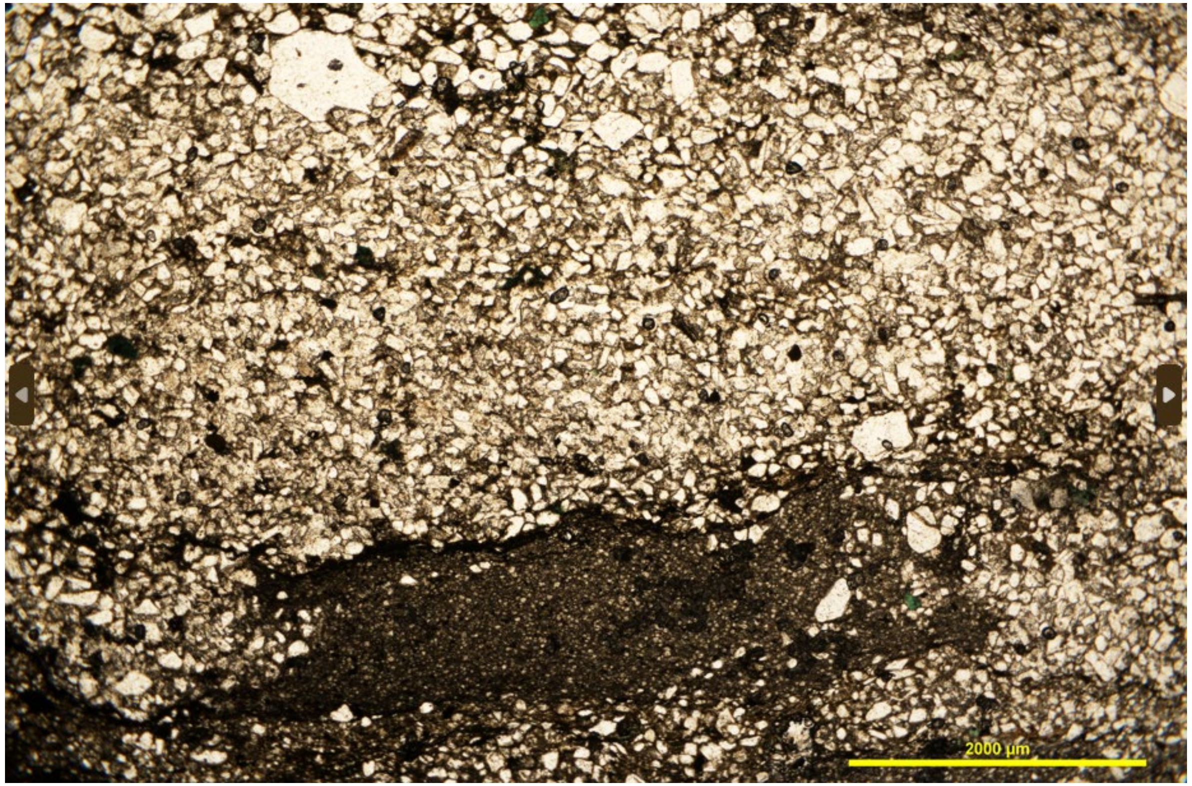
Kerbel Sandstone @ 1038.15m



Dundee East Lake Erie 45-E-4C (T012159), Core #1130
Kerbel @ 1038.15m
FD99 (1038.14-1038.70m)
Porosity = 11.2%, Kmax = 12.90mD
TS1130-72

TS1130-72: Fine sand grade dolomitic sandstone comprising poorly sorted quartz and feldspar grains held in a finely crystalline dolomite matrix. The monocrystalline quartz grains are mostly 0.1 to 0.15 mm long (some up to 0.25 mm). Feldspar grains (including microcline & plagioclase) are intermixed with the quartz grains and tend to be less than 0.15 mm long. The detrital quartz and feldspar grains are held in a very finely crystalline dolomite matrix that probably formed through the replacement of a micrite precursor. Uneven porosity distribution.

Conasauga Marker @ 1043.91m



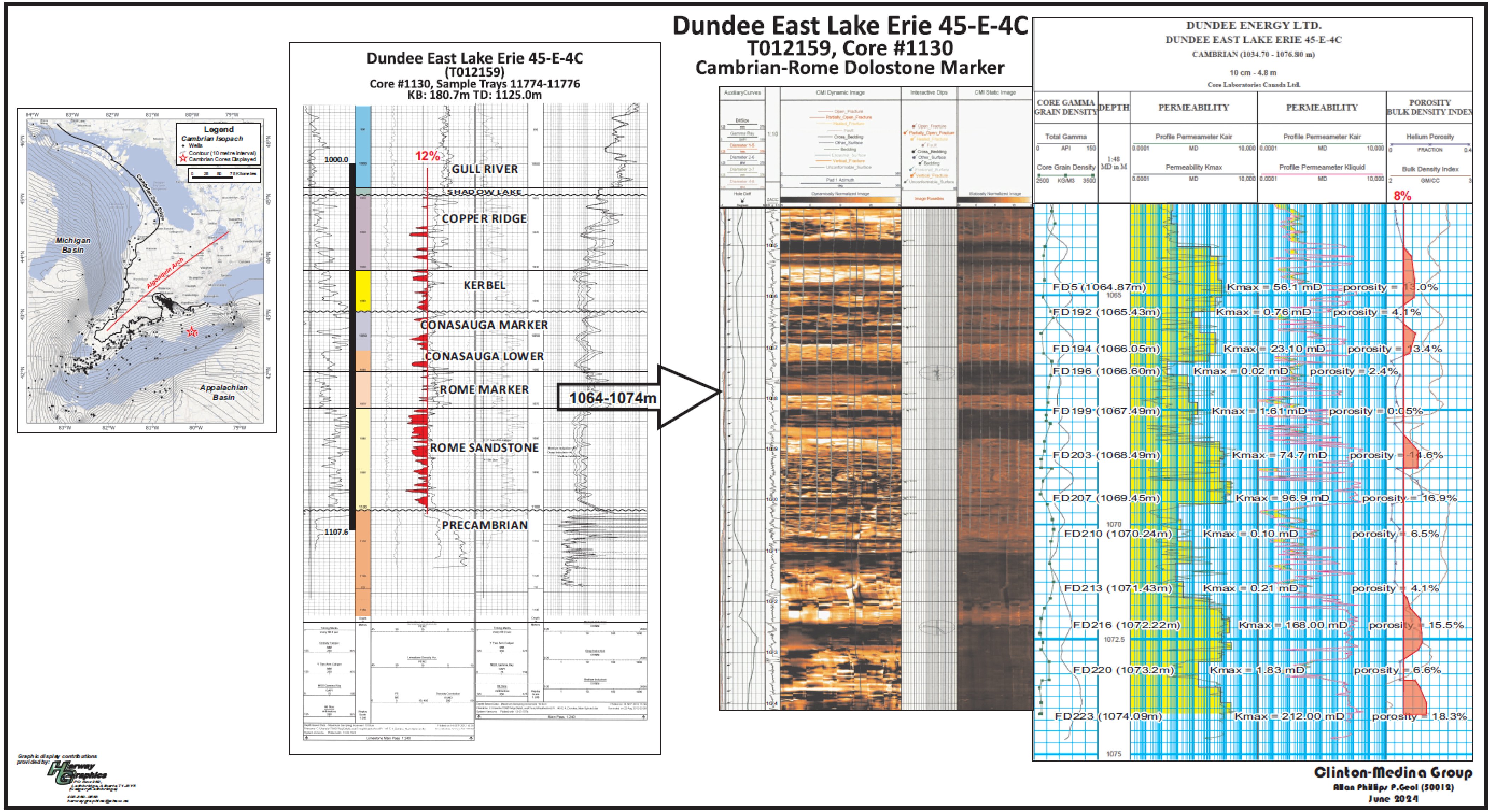
Dundee East Lake Erie 45-E-4C (T012159), Core #1130
Conasauga Marker @ 1043.91m
FD120 (1043.85-1044.25m)
Porosity = 3.4%, Kmax = 0.04mD
TS1130-70

TS1130-70: Fine sand grade dolomitic sandstone comprising tightly packed angular to subangular quartz and feldspar grains held in a dolomite matrix. The monocrystalline quartz grains are mostly 0.1 to 0.15 mm long (some up to 0.25 mm). Feldspar (microcline & plagioclase) grains, typically are about 0.1 mm long, are intermixed with the quartz grains. The detrital quartz and feldspar grains are in a finely crystalline dolomite matrix. Irregular-shaped, fine-grained dolomite patches are mud filled burrows scattered throughout the thin section.

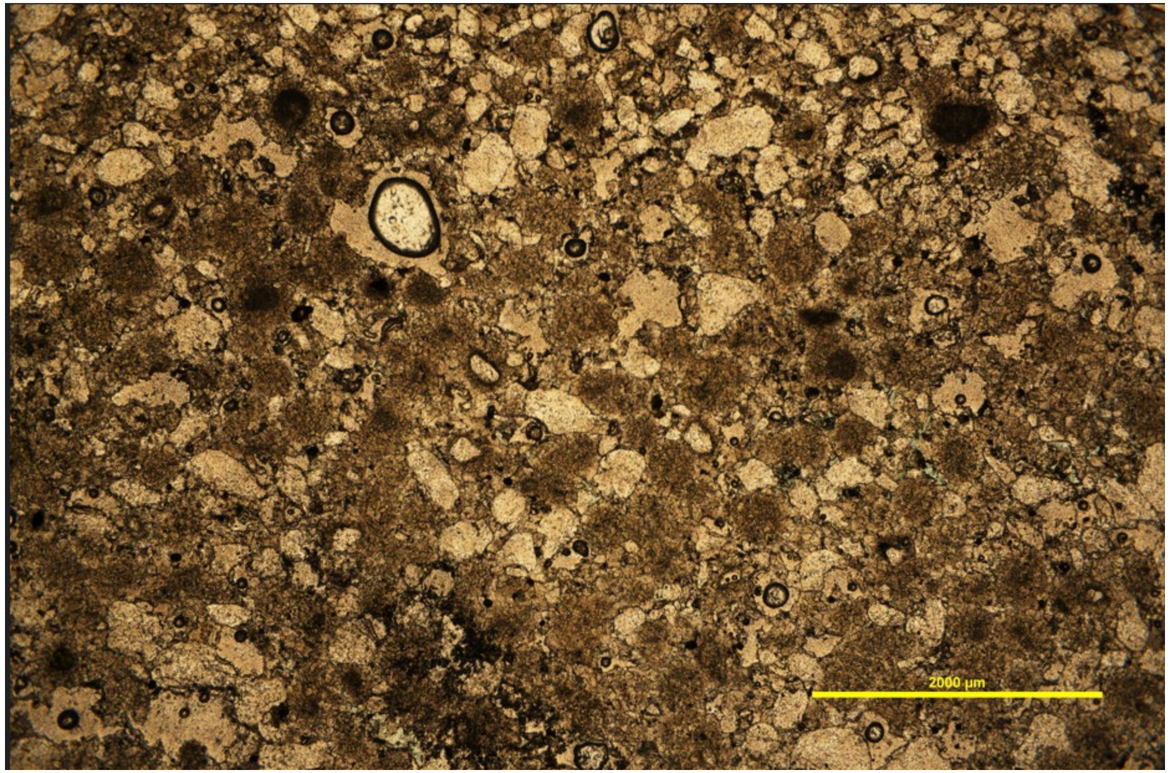
ONTARIO PETROLEUM INSTITUTE INC. O.P.I. DISCOVERED AT OIL SPRINGS 1858 FIRST COMMERCIAL WELL IN NORTH AMERICA

epex 2025
OPI 62nd Conference and Trade Show

Cambrian Rome Dolostone Marker



Rome Dolostone Marker @ 1071.77m

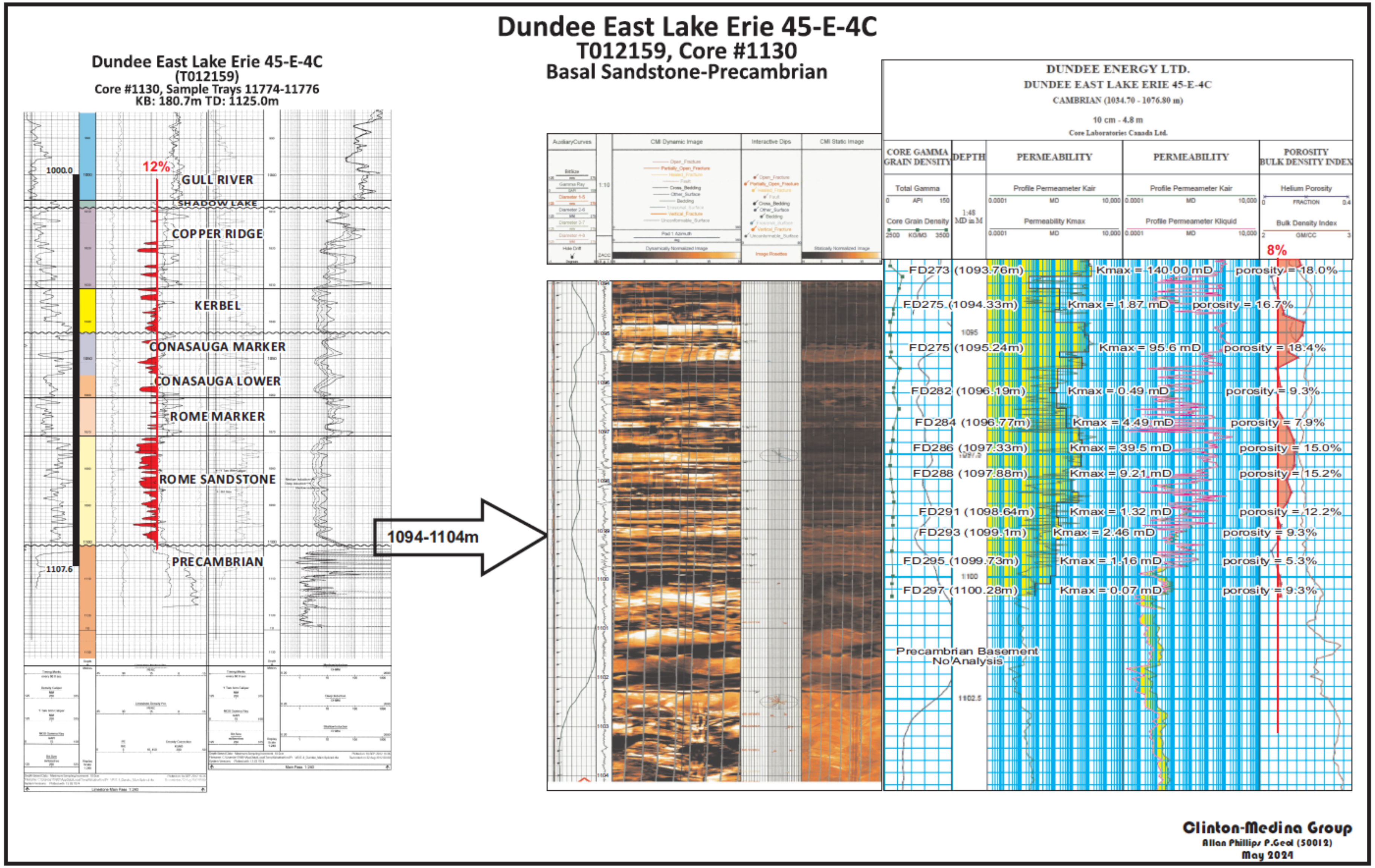


Dundee East Lake Erie 45-E-4C (T012159), Core #1130
Rome Dolostone Marker @ 1071.77m
FD214 (1071.61-1071.83m)
Porosity = 9.5%, Kmax = 8.87mD
TS1130-47

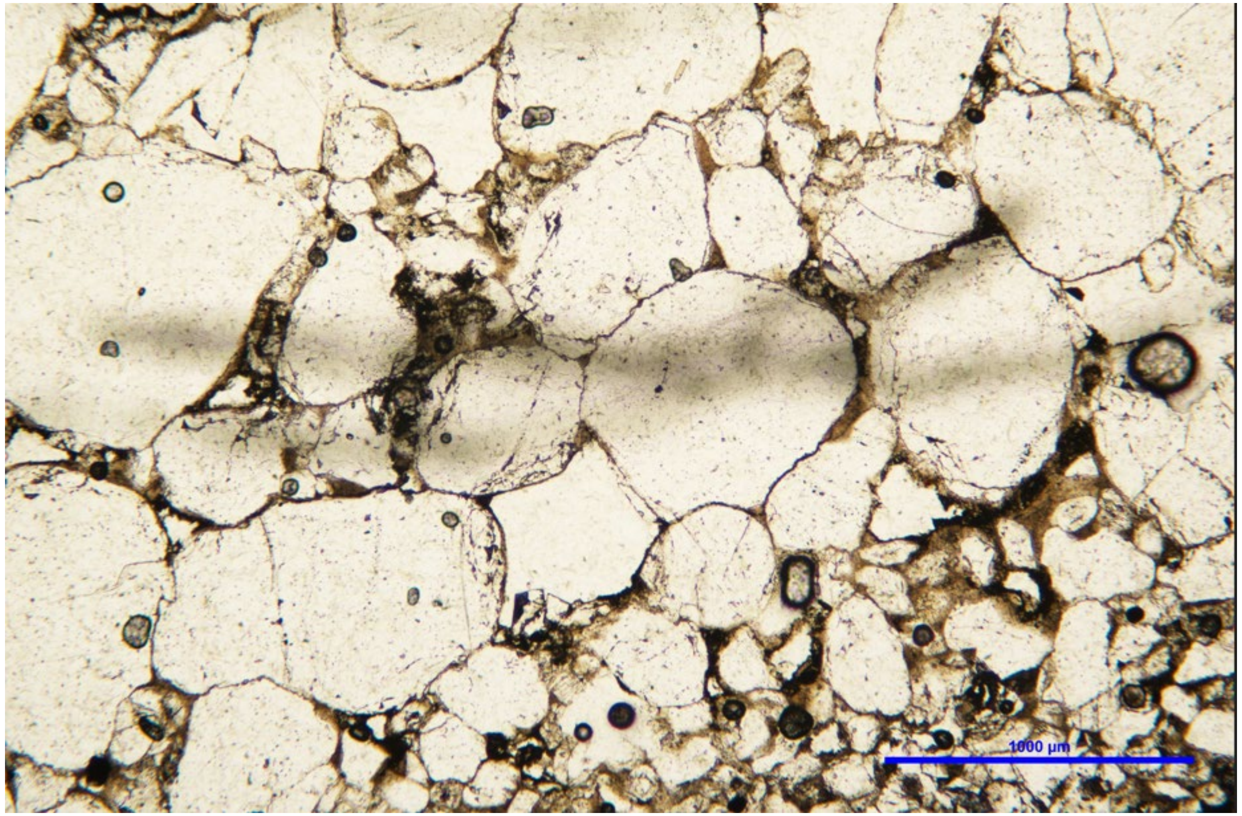
TS1130-47: Sandy dolostone is formed of quartz and feldspar grains held in a dolomite groundmass that is characterized by ghost structures of ooids(?). The quartz and feldspar grains (up to 0.50 mm long) are scattered throughout the dolomite groundmass. The dolomite groundmass has numerous ghost structures of round to slightly ovate allochems (up to 0.5mm in diameter). None of their internal fabric is preserved, but their consistency in size and shape suggest they may have originally been ooids. Porosity is unevenly distributed throughout the thin section.

epex 2025
OPI 62nd Conference and Trade Show

Cambrian Rome Sandstone-Precambrian



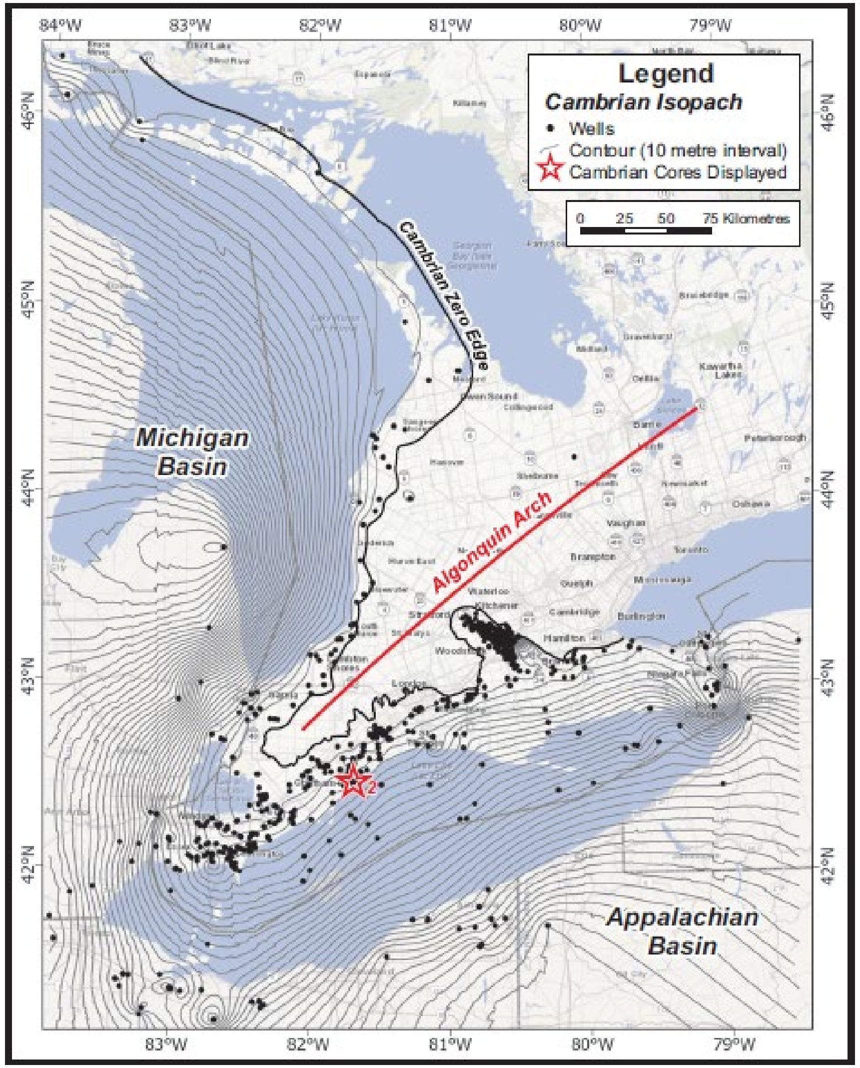
Rome Sandstone @ 1098.38m

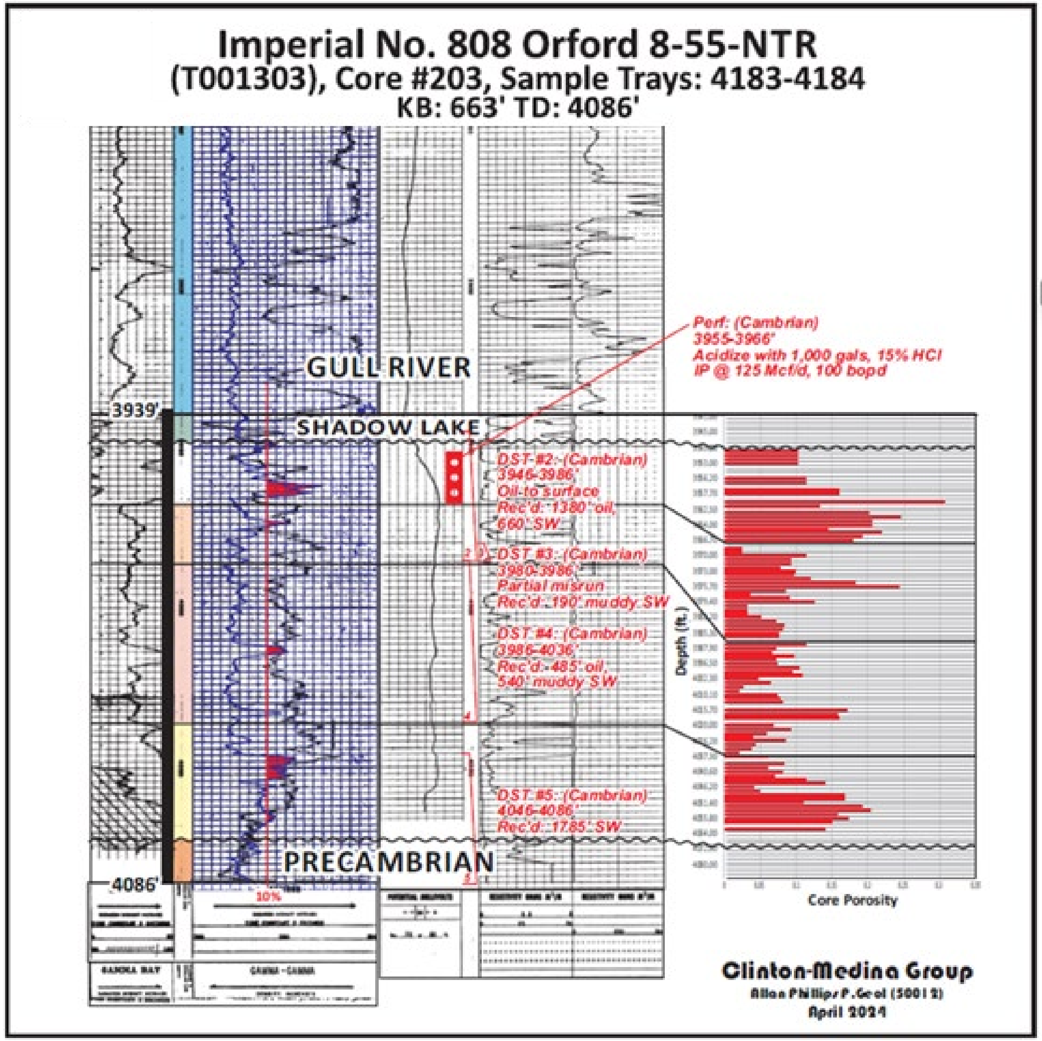


Dundee East Lake Erie 45-E-4C (T012159), Core #1130
Rome Sandstone @ 1098.38m
FD290 (1098.28-1098.49m)
Porosity = 13.9%, Kmax = 23.8mD
TS1130-6

TS1130-6: Poorly sorted sandstone is formed of a mixture of grains that range from angular to subangular grains that are less than 0.1 mm long to subrounded to rounded grains that are up to 1.0 mm long. Some of the larger grains are angular with highly irregular outlines. The feldspar (microcline and plagioclase) are most common in the small grain size fraction. Porosity is unevenly spread throughout the thin sections. Some sandstones are virtually devoid of porosity whereas others have high porosity. Late-stage barite cementing some of the pores.

Imperial No. 808, Orford 8-55-NTR (T001303), Core #203





Shadow Lake Sandstone @ 1204.3m

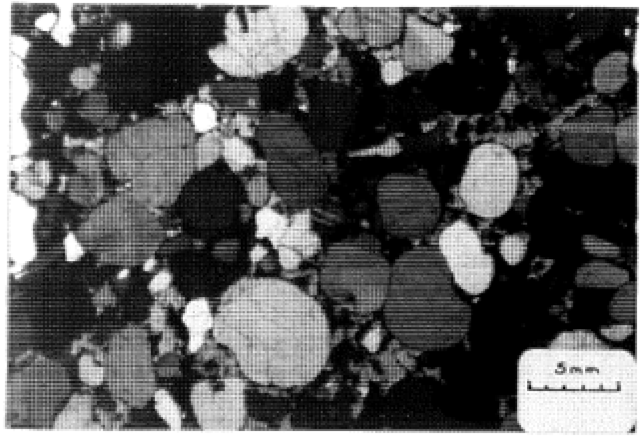


Plate IIIa. Poorly sorted green unconformity sandstone.

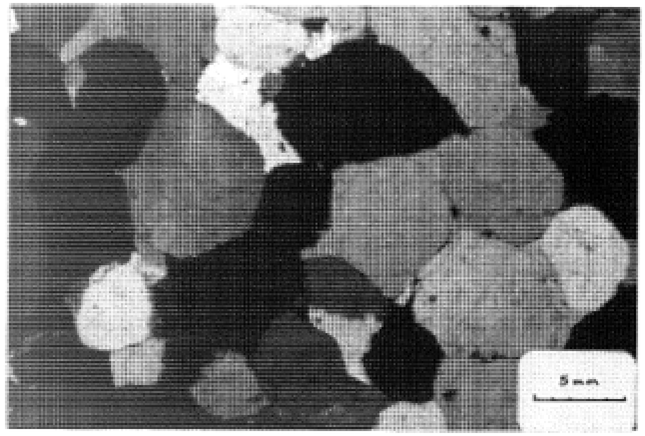


Plate IIIb. Authogenic quartz with original grain boundries. (Green unconformity sand)

Imperial No. 808, Orford 8-55-NTR (T001303), Core #203
Shadow Lake Sandstone @ 1204.3m
Plug 1 (1203.7-1204.0m)
Porosity = 10.2%, Kmax = 6.10mD
McMurray (1984) Plate IIIa, Plate IIIb

“The contact between the Upper Cambrian and the Middle Ordovician is unconformable and marked by the appearance of a well sorted to poorly sorted frosted sandstone with green silty clayey or argillaceous matrix. The sand grains are very friable in places where clay matrix is abundant and tight were cemented with diagenetic silica. (Plate IIIa, b).”

Clearville Oil Zone @ 1210.1-1211.6m

PLATE II

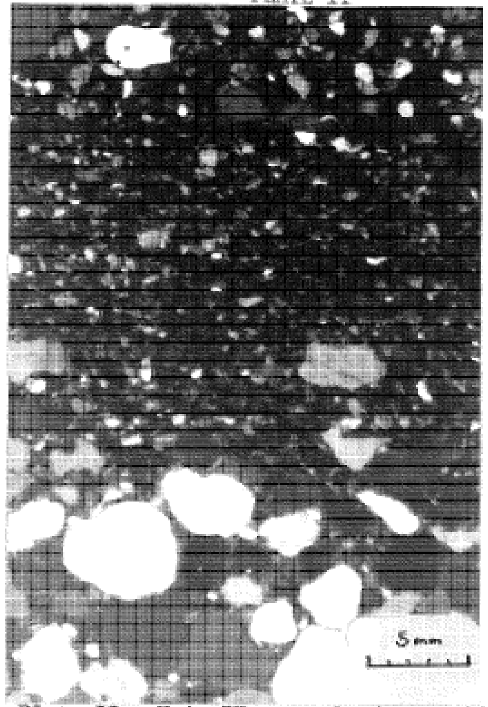


Plate IIa Unit IV top showing rapid interfingering.

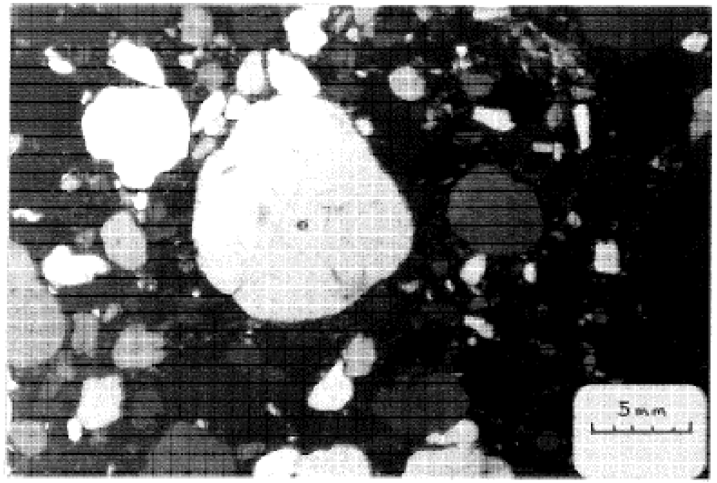
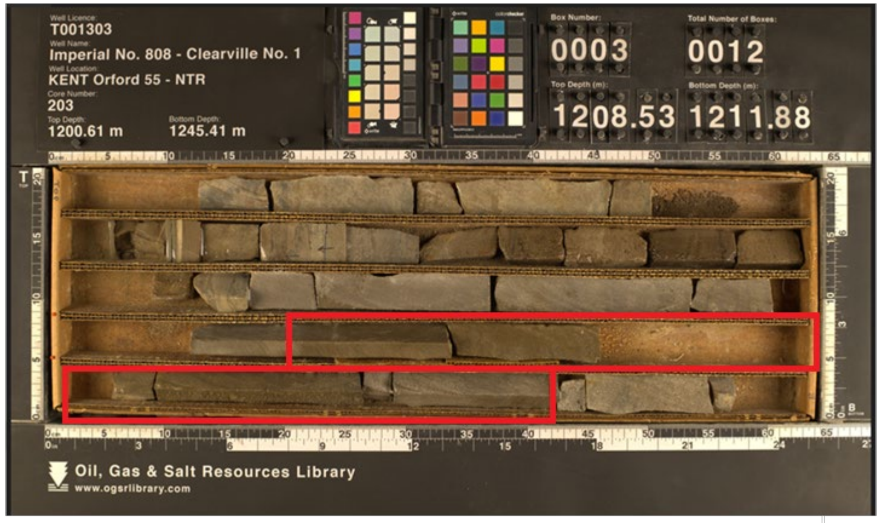


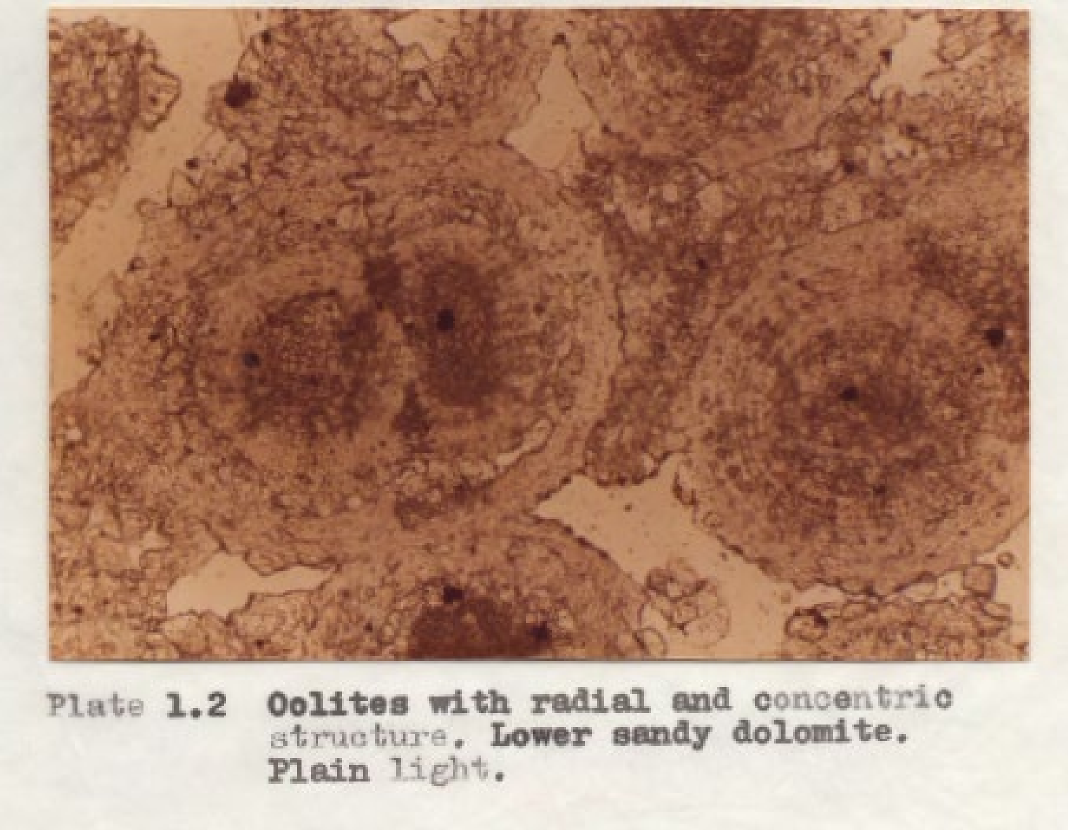
Plate IIb. Poorly sorted but well rounded upper Unit IV sandstone.

"Unit IV is the uppermost Upper Cambrian unit at Clearville. It consists of a clean subangular sandstone with cross-beds in places and interfingering sandy dolostone towards its top. (Plate IIa and IIb) Sand grains become well rounded yet poorly sorted towards the upper contact."



Imperial No. 808, Orford 8-55-NTR (T001303), Core #203
Oil Zone @ 1210.1-1211.6m
Plug 21 (1211.6-1211.8m)
Porosity = 24.3%, Kmax = 298.00mD
McMurray (1984) Plate IIa, IIb

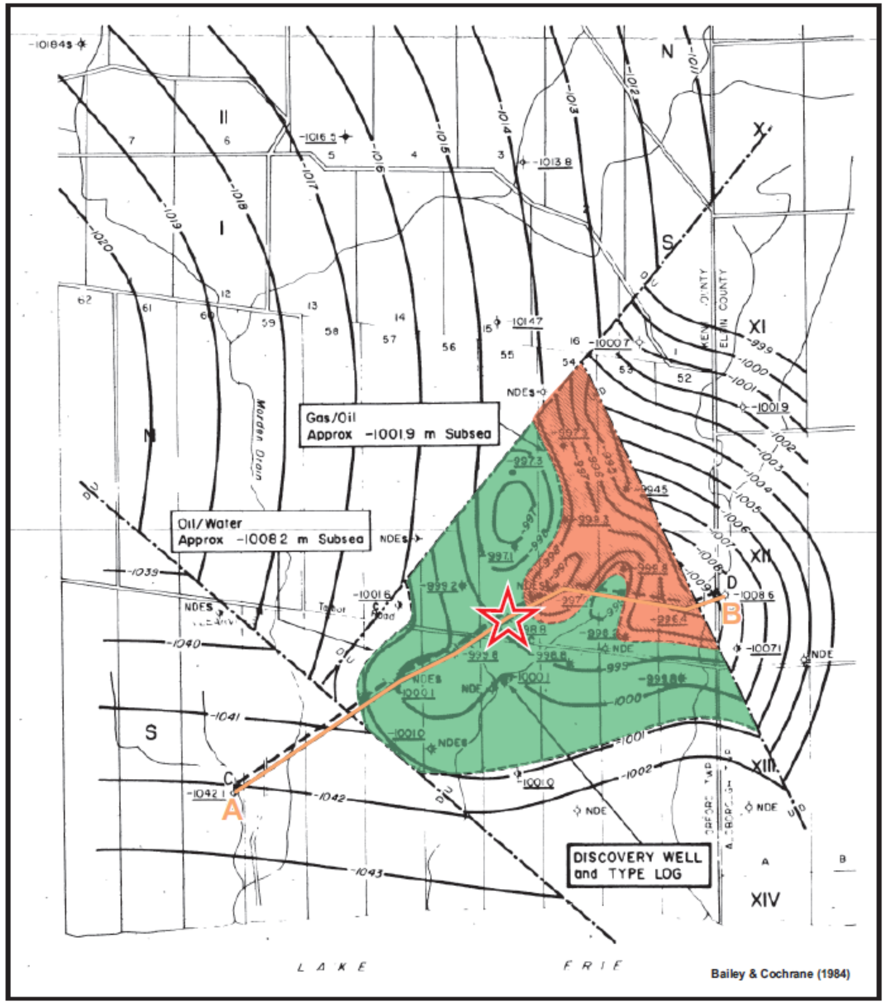
Rome Dolostone @ 1225.9-136.0m



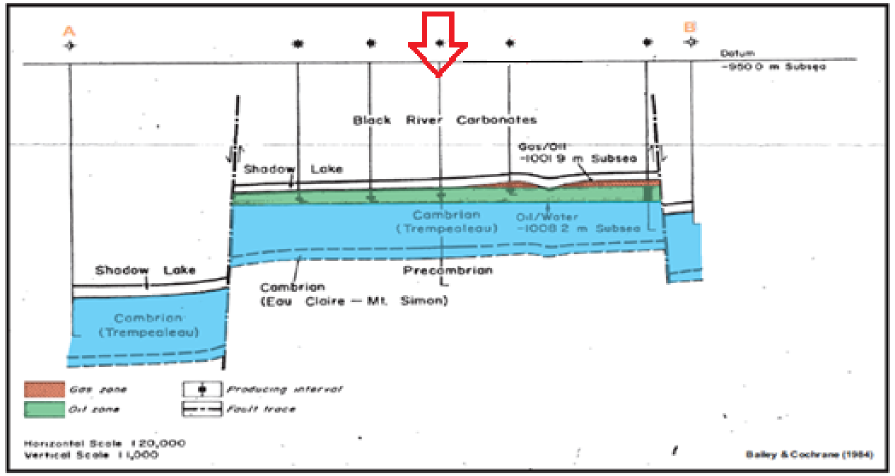
Imperial No. 808, Orford 8-55-NTR (T001303), Core #203
Rome Dolostone Marker @ 1225.9-1236.0m
Plug 61 (1230.9-1231.2m);
Porosity = 6.0%, Kmax = 2.00mD
Korpan (1984) Plate 1.2

"The lower sandy dolomite is light olive grey to olive grey mottled, microcrystalline and commonly oolitic with fine to medium quartzose grains suspended in varying concentrations throughout. The unit is thinly interlayered with grain-supported quartzose sandstones occurring in continuous and discontinuous wavy beds up to 4 cm in thickness.
Small vugs up to 4 mm in diameter are commonly found towards the base lined with sparry dolomite and occasional pyrite crystals."

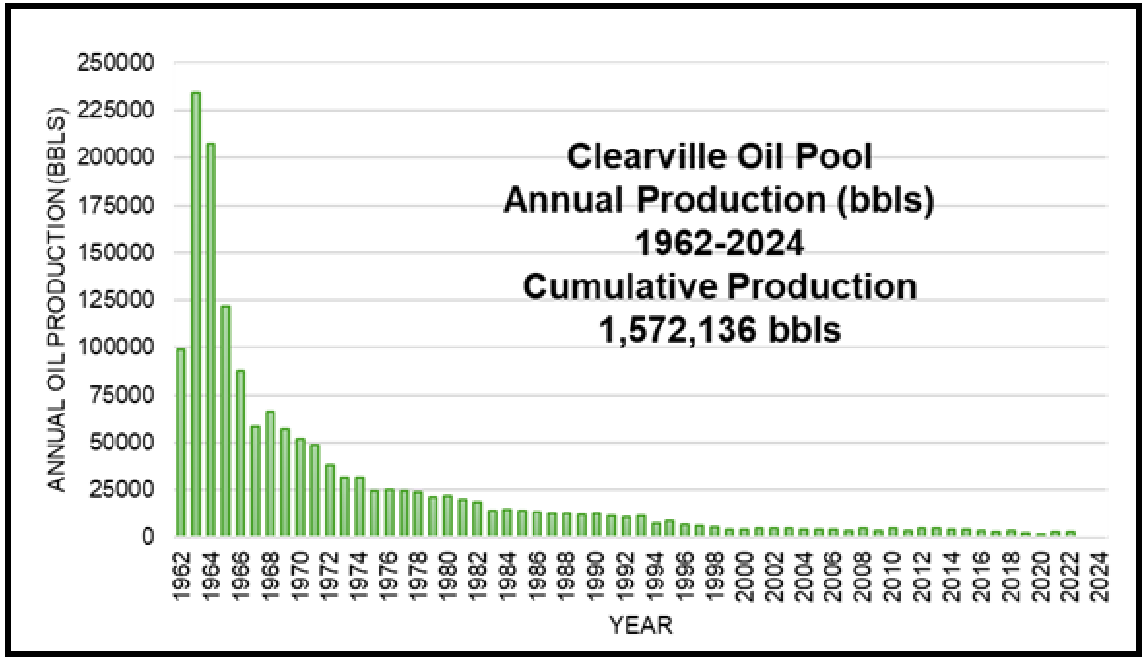
Clearville Oil Pool – Kent County, Orford Township



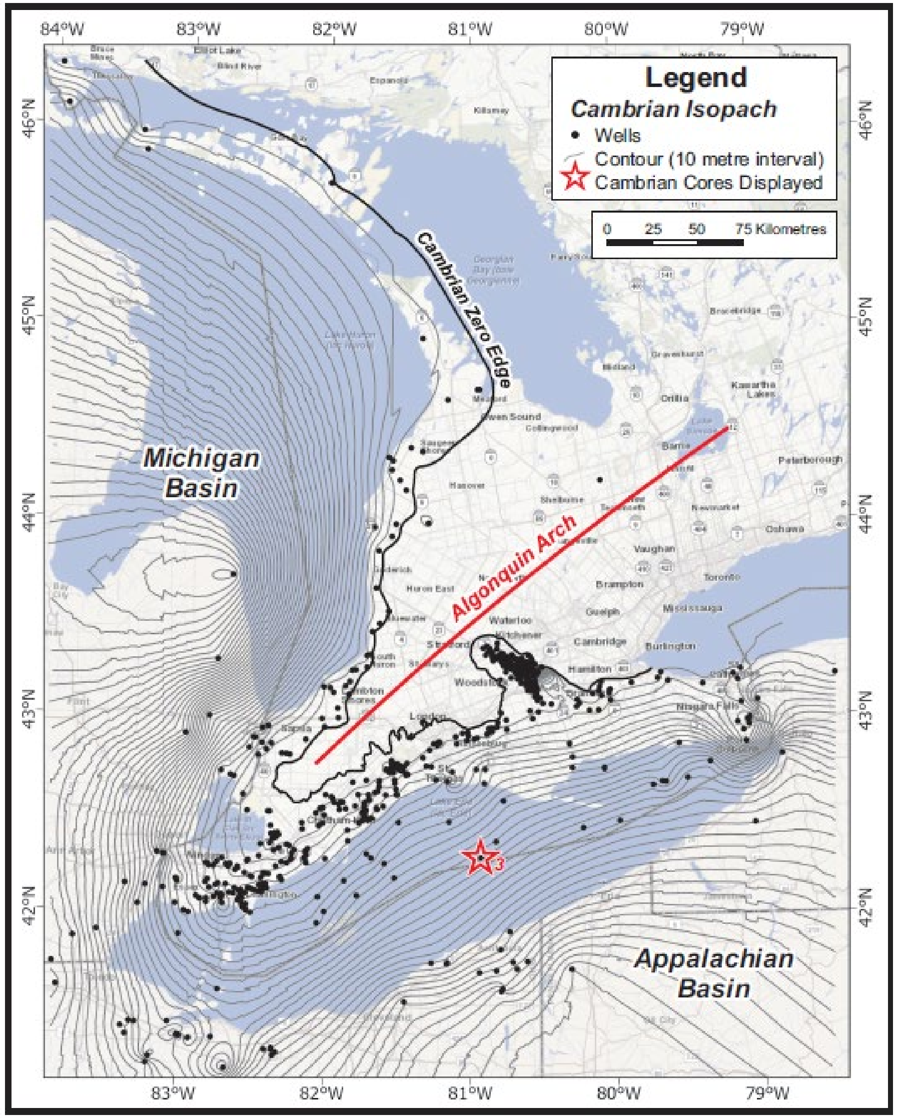
Bailey & Cochrane (1984)

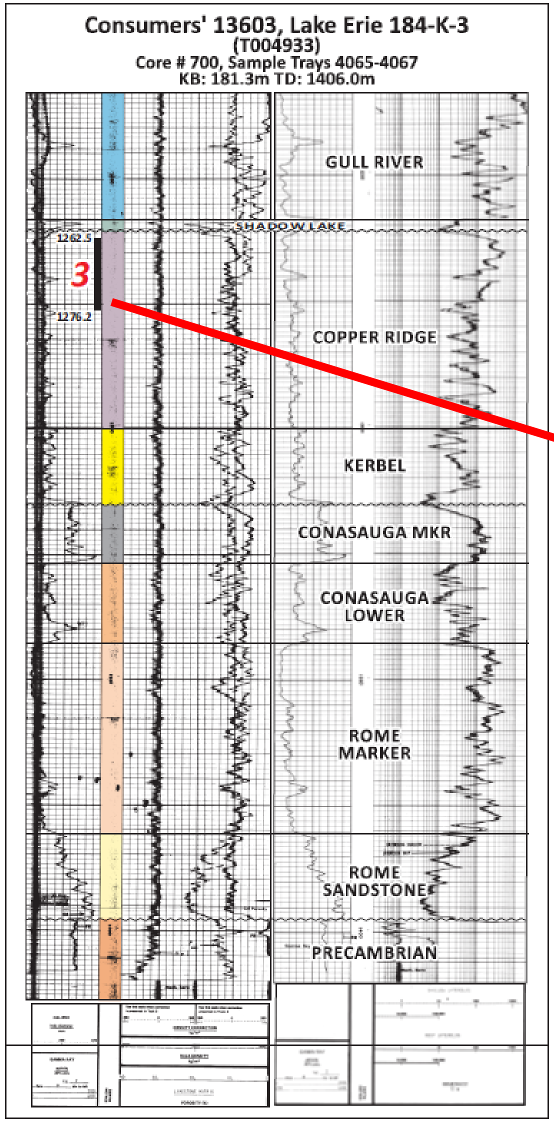


Bailey & Cochrane (1984)

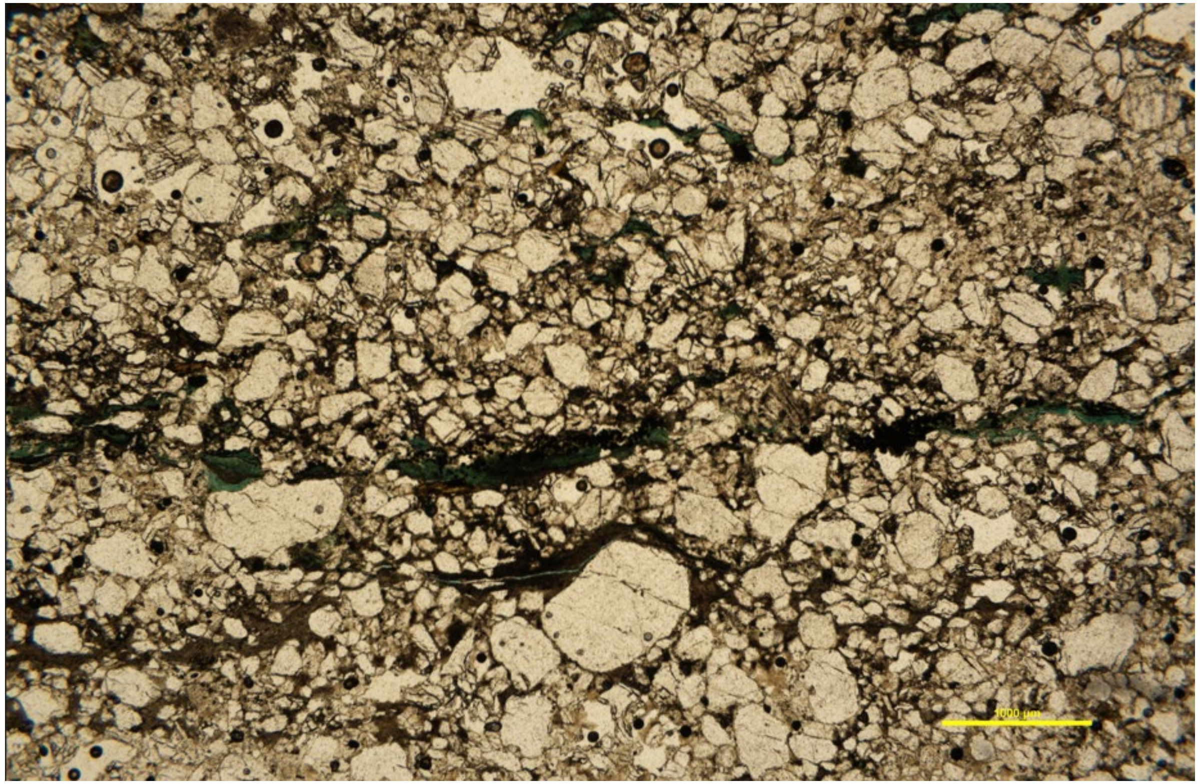


Consumers' 13603, Lake Erie 184-K-3 (T004933), Core #700





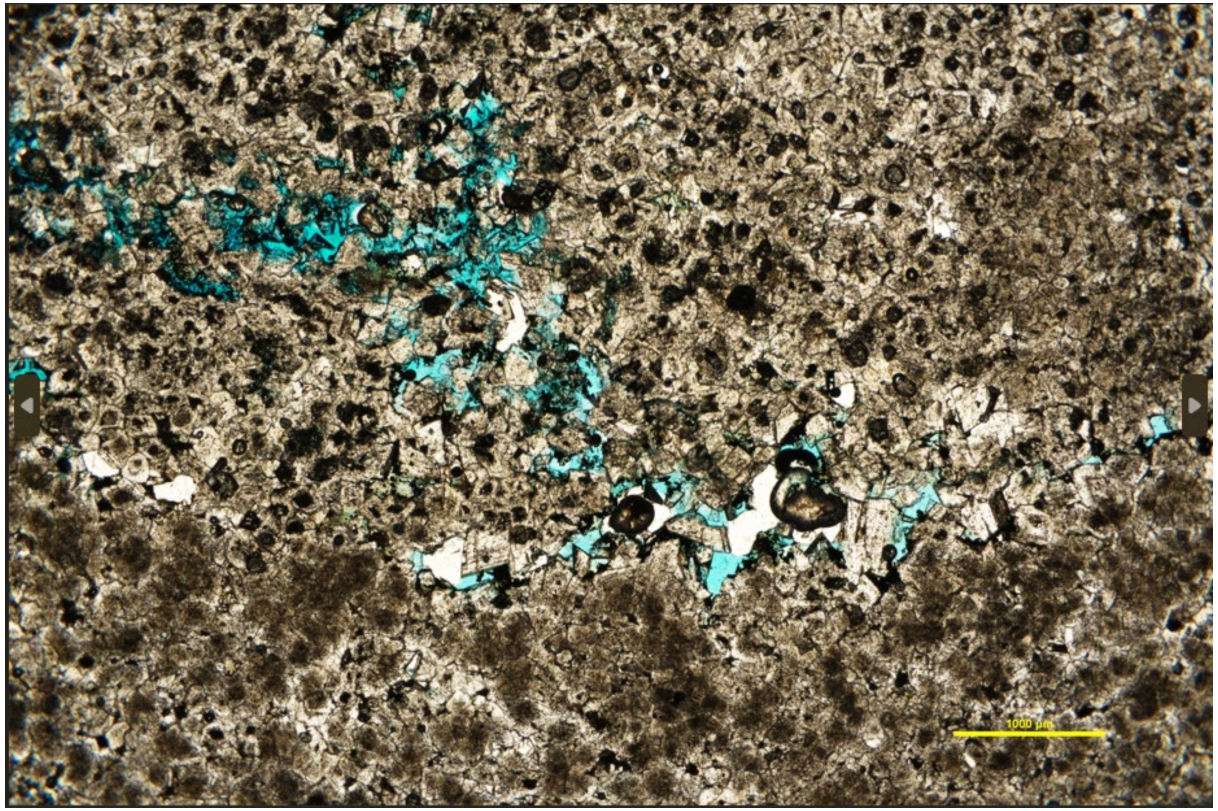
Copper Ridge Sandstone @ 1274.96m



Consumers' 13603 Lake Erie 184-K-3 (T004933), Core #700
Copper Ridge Sandstone @ 1274.96m
FD39 (1274.73-1274.86m)
Porosity = 5.2%, Kmax = 1.20mD
TS700-5

TS700-5: Poorly sorted sandstone comprises mixture of angular to subangular grains that are less than 0.1 mm long to subrounded to rounded grains that are up to 1.0 mm long. The feldspar (microcline and plagioclase) grains are most common in the smaller grain size fraction. The dark laminae running through the middle of the photomicrograph appears to be dark brown organic matter and green glauconite.

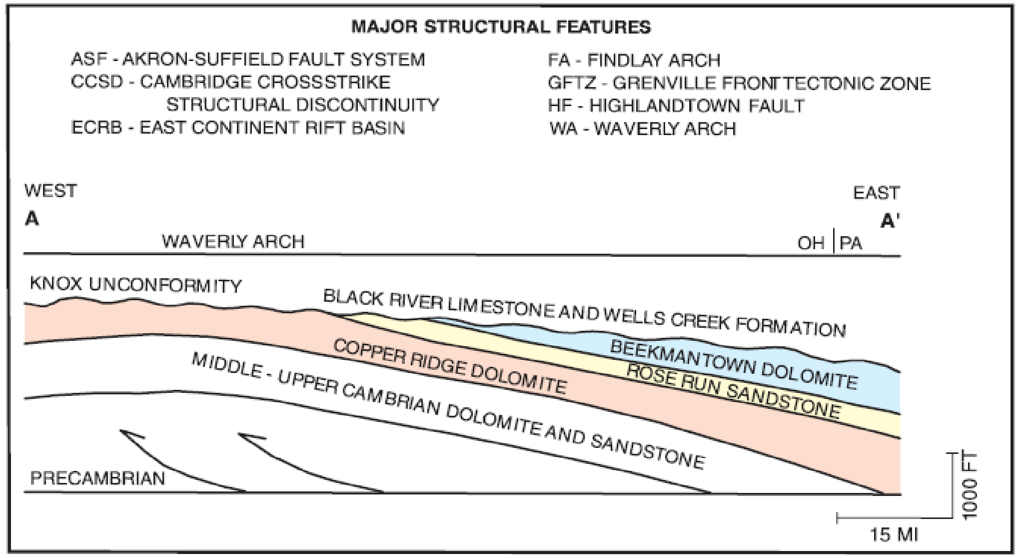
Copper Ridge Dolostone @ 1268.10m



Consumers' 13603 Lake Erie 184-K-3
(T004933), Core #700
Copper Ridge Dolostone @ 1268.10m
FD19 (1268.10-1268.24m)
Porosity = 3.6%, Kmax = 74.00mD
TS700-3

TS700-3: Vuggy dolostone. Finely crystalline dolomite groundmass with rare quartz and feldspar grains. The anhedral crystals in the matrix form a tightly interlocking mass. Porosity is in the form of irregular shaped vugs (blue) up to 5 mm long, that are present in the centre of the photomicrograph. The vugs are partially filled with dolomite cement and pyrite. The dolomite cement is more coarsely crystalline. This portion of the thin section is from the edge of a rounded mass (burrow fill) and the cleaner dolomite rhombs above the blue porosity are in the burrow trace.

Knox Unconformity Subcrop Play



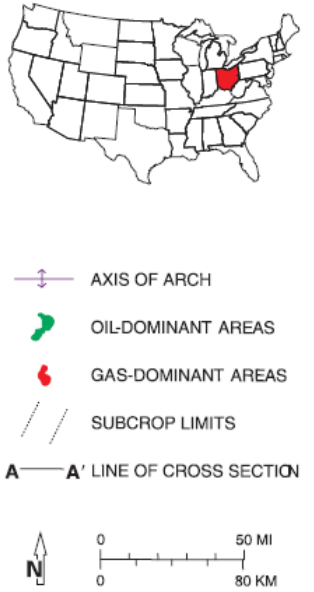
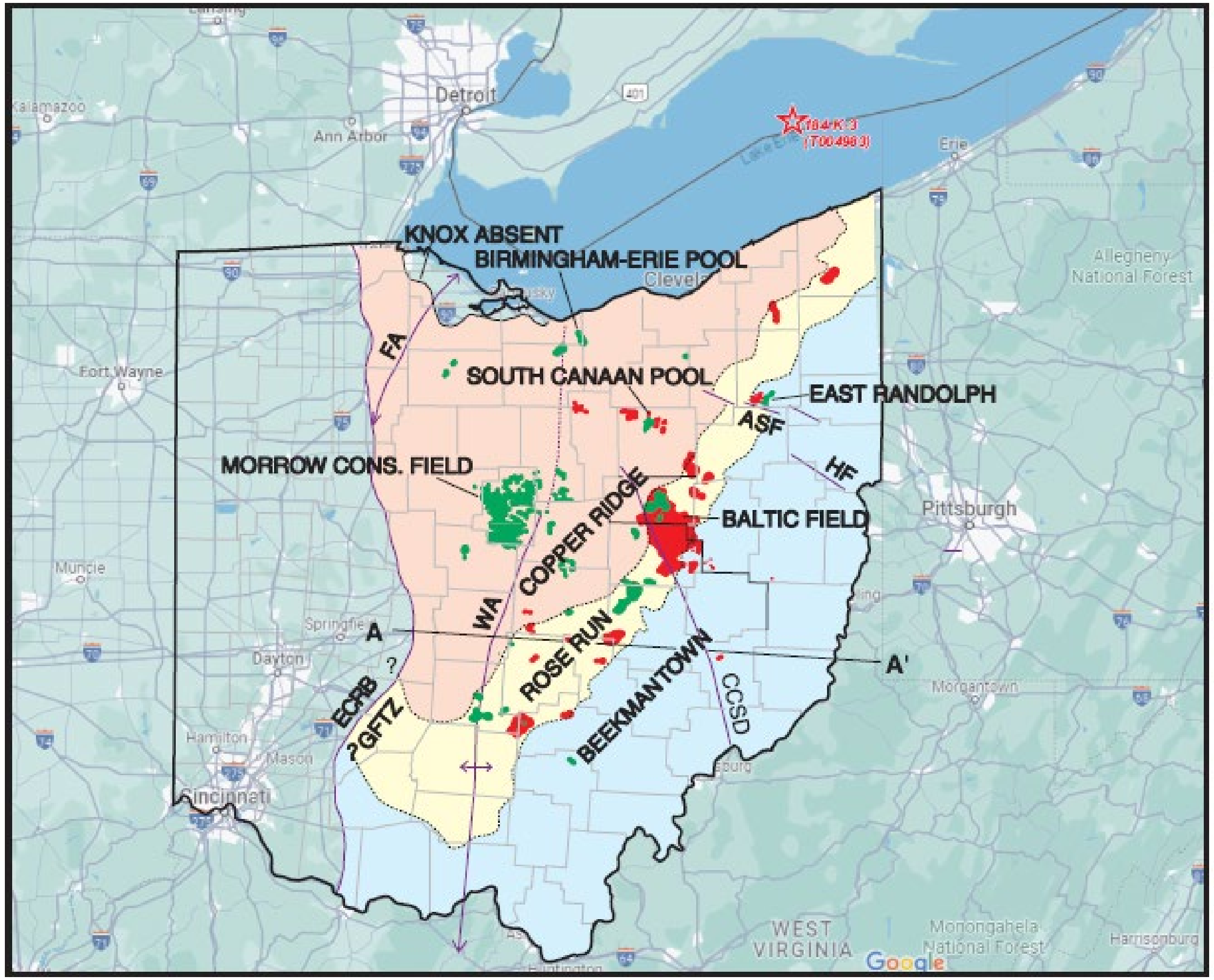
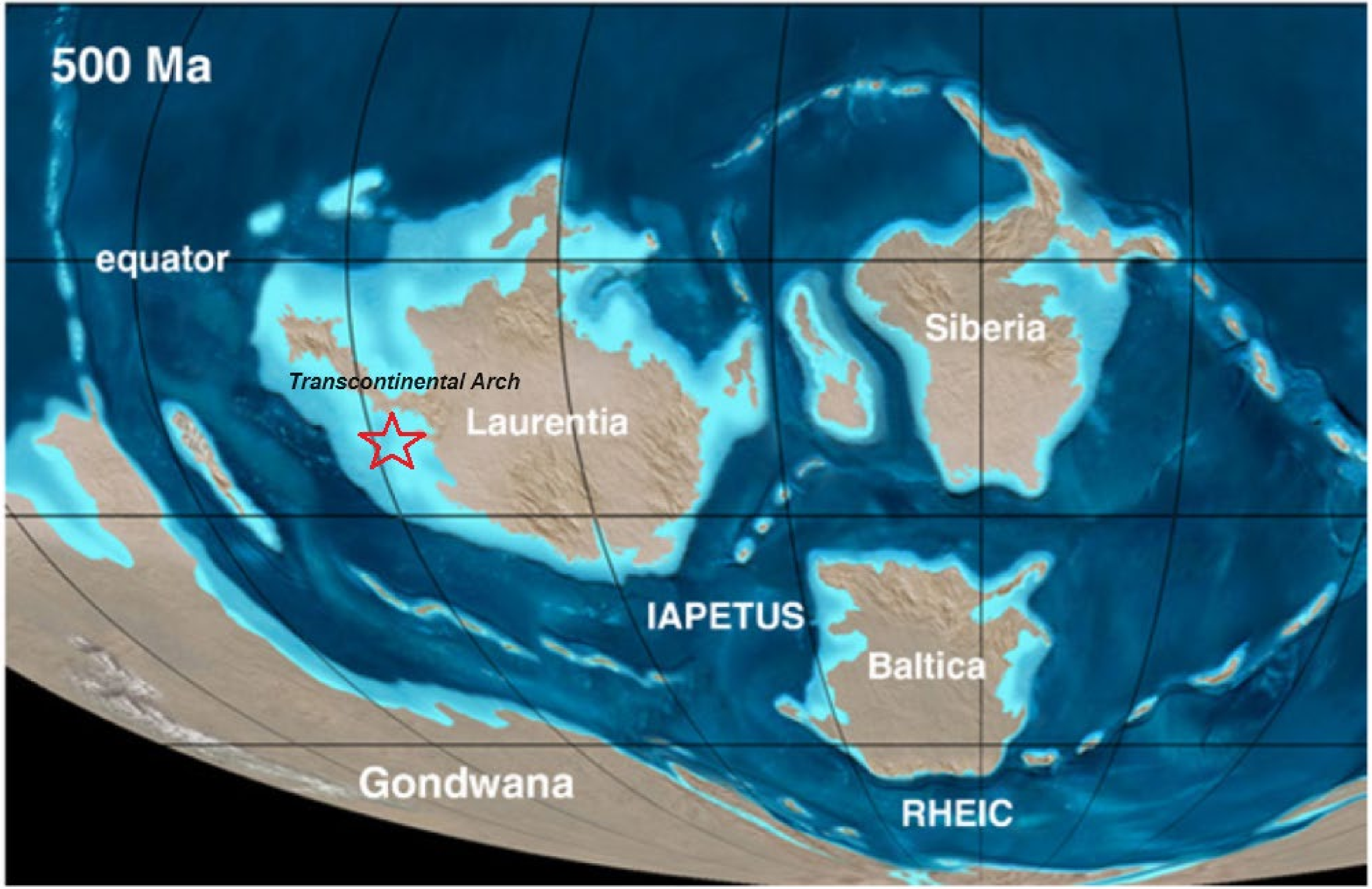


Figure 1. Map showing Cambrian–Ordovician Knox oil and gas pools/fields in Ohio. Also shown are the Knox subcrop trends and major structural features present during Knox time. Subcrop in western Ohio is uncertain because of limited well control and is not shown. Major structural elements and basement features are from Baranoski and Wickstrom (1991). Diagrammatic cross section is not to scale.

Riley et al (2002)



Upper Cambrian paleogeographic setting, Laurentia is surrounded by passive margins with much of the continent covered by shallow seas.



modified from Calner et al (2013)

Acknowledgements:

- We would like to thank Kei Yeung with the Ontario Geologic Survey for his support on this project.
- Thank you to all the staff for your prepping core, core photography, and gathering data at the Ontario Oil, Gas & Salt Resource Library in London, Ontario.
- We also thank Linda and Bill Harrison at WMU Geological & Environmental Services Staff at Michigan Geological Repository for Research & Education in Kalamazoo, Michigan.
- Jeffery Deisher and Madge Fitak at the H.R. Collins Laboratory & Geological Sample Repository in Columbus, Ohio for access to select cores and well data.
- Stephen Wood is thanked for thin section preparation at the University of Western Ontario, London, Ontario.
- Sandra Clarke and Thomas Gore of OGS GeoLaboratory Mineralogy Lab are thanked for thin section scanning and SEM studies of select thin sections.

Bibliography:

Armstrong, D.K. and Carter, T.R. 2010. The subsurface Paleozoic stratigraphy of southern Ontario; Ontario Geological Survey, Special Volume 7, 301p.

Bailey Geological Services Ltd. and Cochrane, R.O. 1984. Evaluation of the conventional and potential oil and gas reserves of the Cambrian of Ontario; Ontario Geological Survey, Open File Report 5499, 72p.

Baranoski, M.T. and Wickstrom, L.H. 1991. Map of basement structures in Ohio: Ohio Division of Geological Survey, DCMS-7, scale 1:500,000, 1 sheet.

Brunton, F.R. 2024. Overview of Paleozoic Bedrock and Karst Mapping Initiatives and the New OGS Lithostratigraphic Chart for Southern Ontario; Ontario Geologic Survey Virtual Showcase 2024, Day 3, November 28, 2024.

Calner, M., Ahlberg, P., Lehnert, O. and Erlström, M. (eds.), 2013. The Lower Palaeozoic of southern Sweden and the Oslo Region, Norway. Field Guide for the 3rd Annual Meeting of the IGCP project 591. Sveriges geologiska undersökning Rapporter och meddelanden 133, 96 p.

Harkness, R.B. 1924. Natural Gas in 1923 and Petroleum in 1923. Ontario Department of Mines Twenty third annual report Volume XXXIII, Part V, 105p.

Janssens, A. 1973. Stratigraphy of the Cambrian and lower Ordovician rocks in Ohio; Ohio Division of Geological Survey Bulletin 64, 197p.

Korpan, M. 1984. Cambrian stratigraphy and reservoir geology of the Clearville oil field; HBSc. Thesis, Department of Geology, University of Windsor, Windsor, Ontario, 73p.

McMurray, M.G. 1984. Upper Cambrian geology of the Clearville oil pool, southwestern Ontario; HBSc. Thesis, Department of Geology, University of Western Ontario, London, Ontario, 55p.

Phillips A.R., Brunton F.R. and Yeung K.H. 2024. Revisiting the Cambrian stratigraphy of southwestern Ontario, an update; EPEX 2024, Ontario Petroleum Institute 61st Conference and trade show oral presentation, London Ontario, June 5, 2024.

Riley, R.A., Wicks. J., and Thomas, J. 2002. Cambrian-Ordovician Knox production in Ohio: Three case studies of structural-stratigraphic traps. American Association of Petroleum Geologists Bulletin, v. 86, No. 4, (April 2002), 17p.

Sanford, B.V. and Quillian, R.G. 1959. Subsurface stratigraphy of Upper Cambrian rocks in southwestern Ontario; Geological Survey of Canada, Paper 58-12, 33p.

Shafeen, A., Croiset, E., Douglas, P.L., and Chatzis, I. 2004. CO2 sequestration in Ontario, Canada. Part I: storage evaluation of potential reservoirs; Energy Conversion and Management, v. 45, 15p.

Trevail, R.A. 1990. Cambro–Ordovician shallow water sediments, London area, southwestern Ontario; *in* Subsurface geology of southwestern Ontario: A core workshop; American Association of Petroleum Geologists, 1990 Eastern section Meeting, London, Ontario. p.29-50.