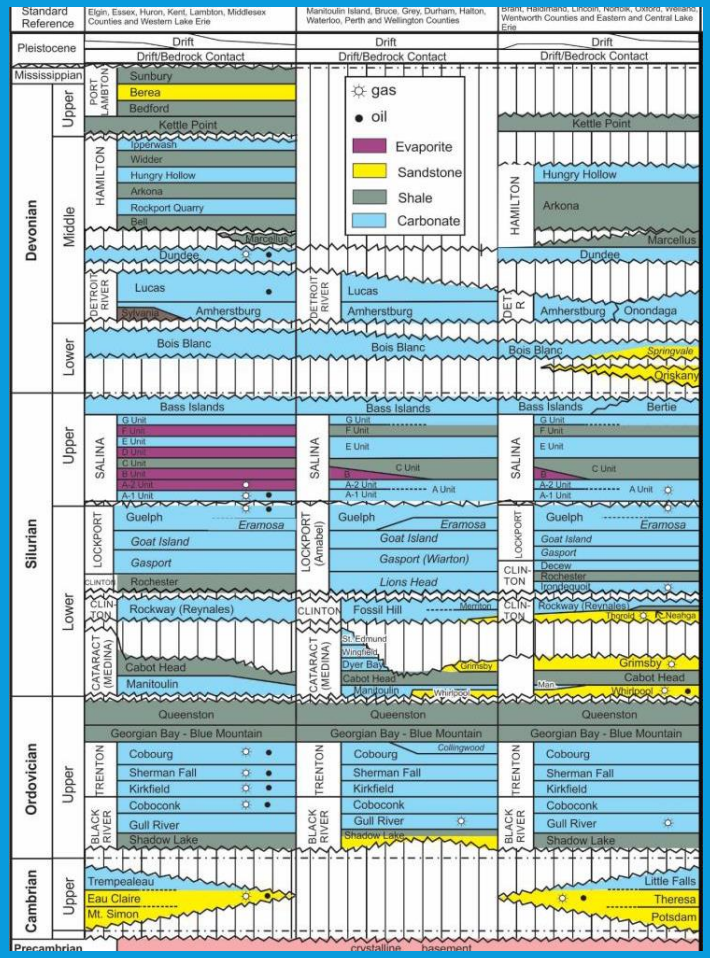
SILURIAN REEF PLAY IN ONTARIO

Allan Phillips (Clinton-Medina Group)

MIDDLE AND UPPER SILURIAN CARBONATES AND EVAPORATES

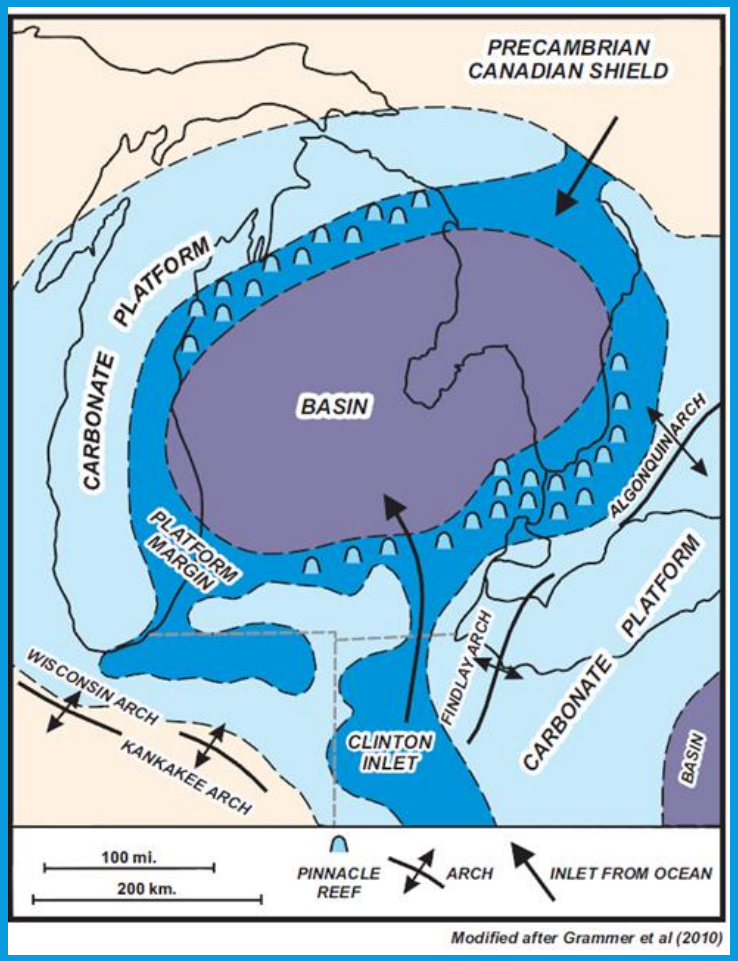


Middle and Upper Silurian age carbonate and evaporite sequence in Lambton, Kent, Essex Counties onshore Ontario and offshore in the western and central basins of Lake Erie.

Guelph-Lockport Group reef buildups sealed with evaporites of the overlying Salina Group.

Structural and stratigraphic traps of banded carbonates within the basal portion of the Salina Group (A1 Carbonate and A2 Carbonate)

FOCUS ON THE SOUTHEASTERN RIM OF MICHIGAN BASIN



Silurian carbonate reservoirs on the southeastern rim of the Michigan Basin in southwestern Ontario.

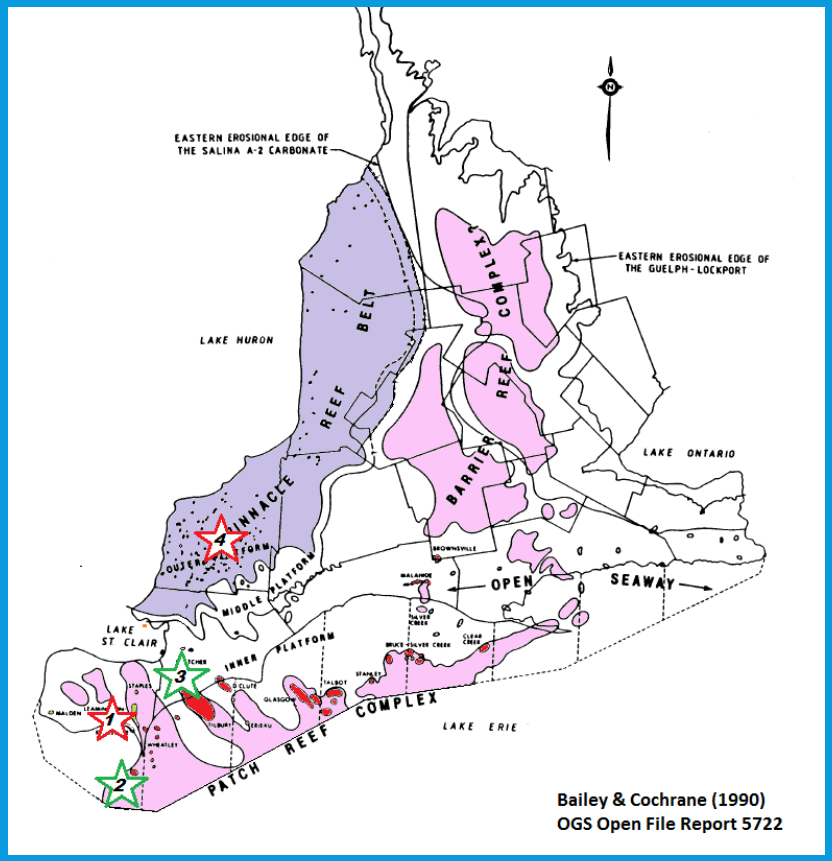
Shallow drill depth to top of reservoir is 230-780m (750-2560').

Natural gas is the predominate hydrocarbon trapped in these reservoirs that straddle basin rimming arches.

THE EARLY DAYS

Eugene Coste "Father of Natural Gas in Canada"

EARLY GUELPH OIL AND GAS DISCOVERIES



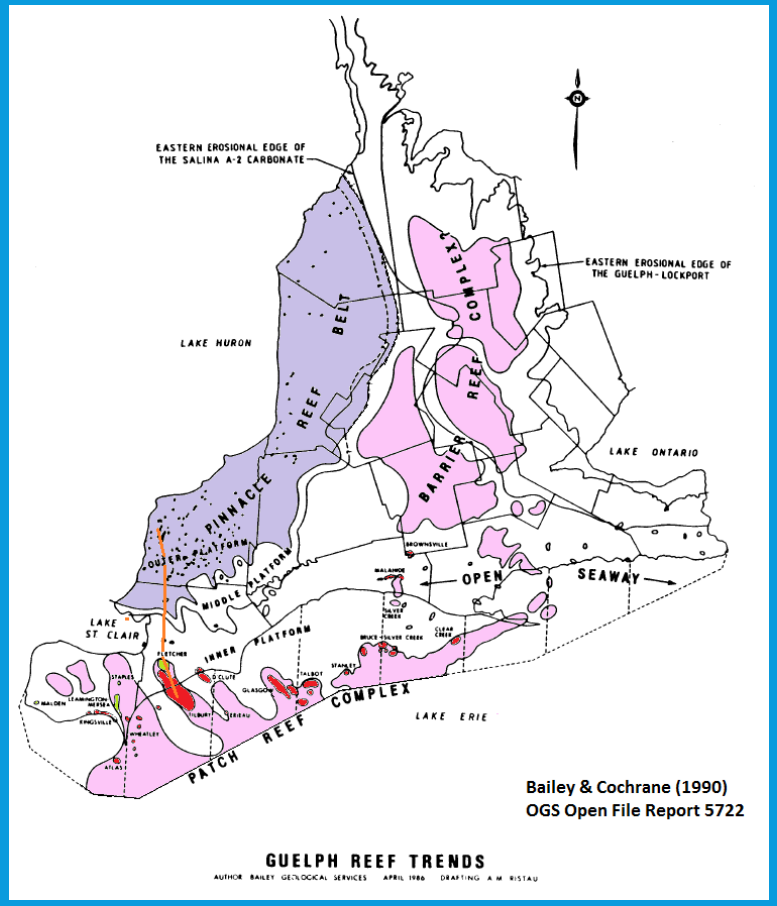
1.Coste No.1, (Kingsville Pool), January 23, 1889 struck gas at 1020' flowing at 10 MMcf/d.

2. Oil discovered on Pelee Island in 1895. Most wells were modest producers 2-6 bopd with some gas at a depth of 740-750'.

3. Acme Oil No.1 (Fletcher Pool), December , 1905 struck gas at 1360' and oil @ 1385' flowed oil at 40 bopd.

4. Fairbank Gusher (Oil Springs), March 7, 1914, struck gas at 1900' flowing 11 MMcf/d.

GUELPH (NIAGARAN) REEF TRENDS



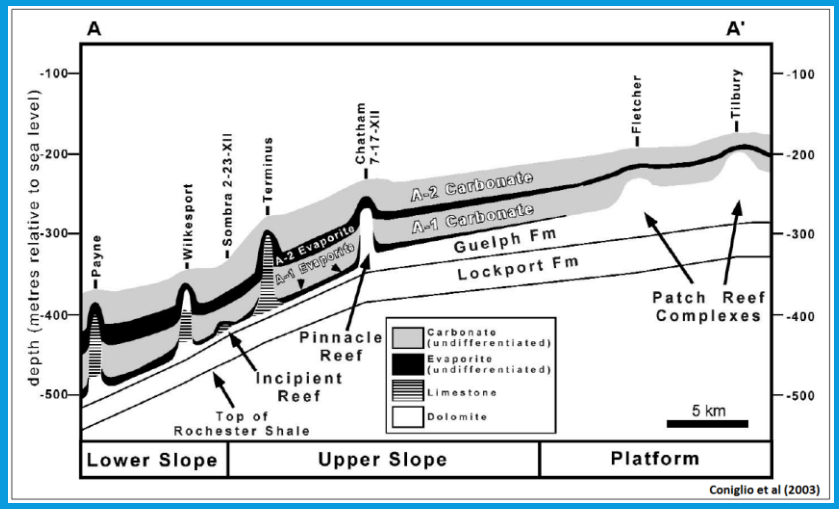
Bailey & Cochrane (1990)
OGS Open File Report 5722

Barrier-Patch Reef Complex

Pinnacle Reef Belt

Pinnacle Reef > 50m (164')

Incipient Reef < 50m (164')



GUELPH PATCH-BARRIER REEFS

Buildups on the basin rimming carbonate complex.

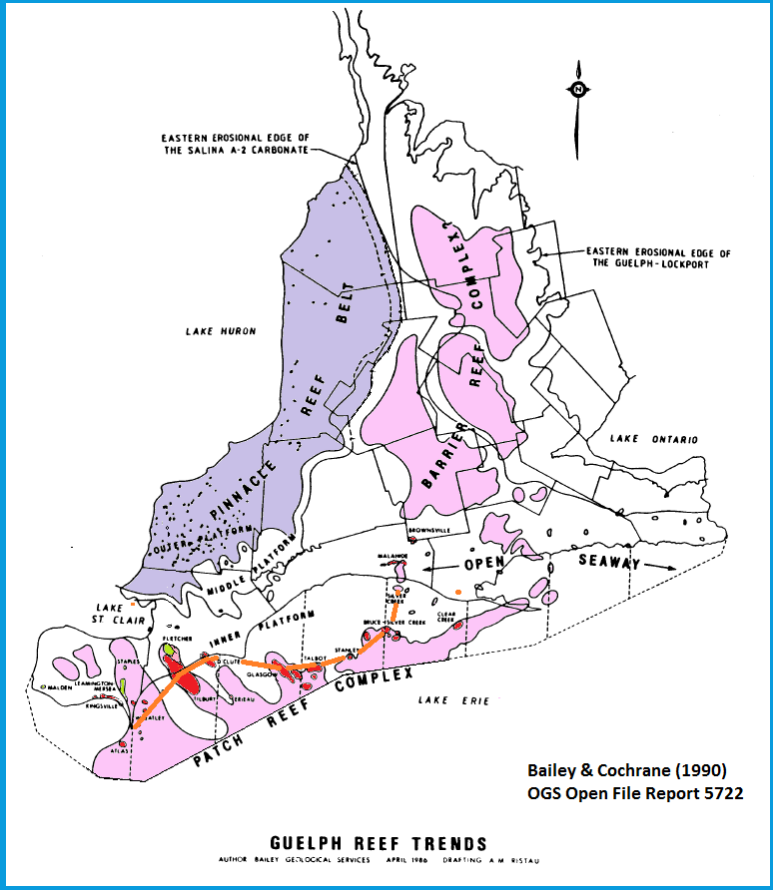
Kingsville-Leamington, Fletcher, Tilbury, D'Clute (1889-1910)

wildcat drilling, well witching, divining, trendology

Tilbury-D'Clute Offshore, Glasgow-Talbot (1913-1977)

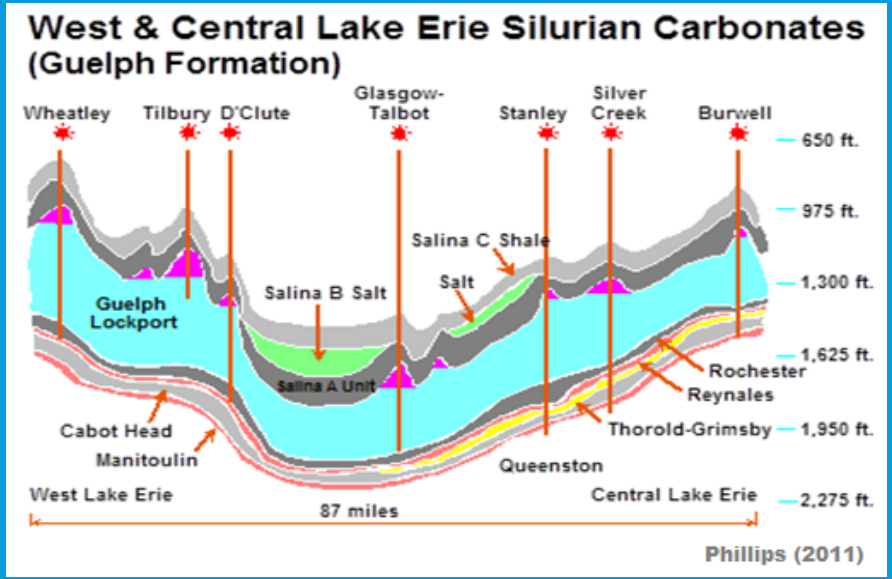
trendology, shallow structure mapping, gravity, seismic

GUELPH PATCH-BARRIER REEFS WEST & CENTRAL LAKE ERIE

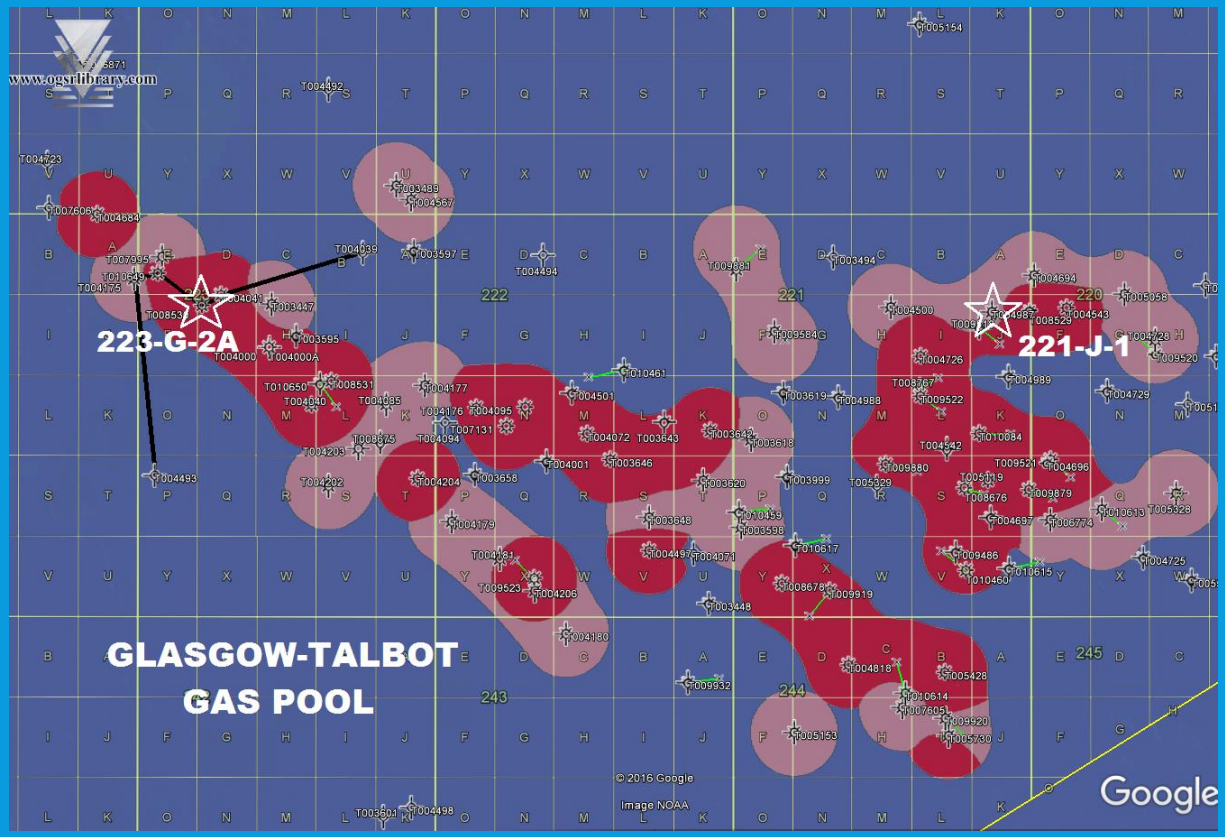


Bailey & Cochrane (1990)
OGS Open File Report 5722

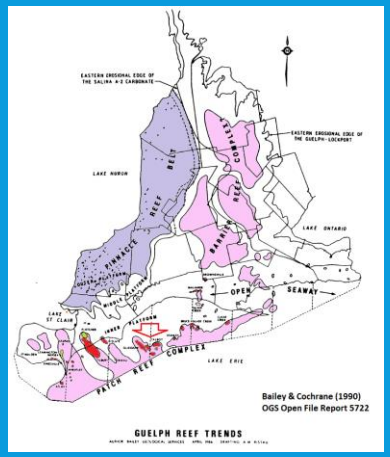
Natural gas is trapped in the crest of reef buildups along the 100 plus mile platform reef complex.



GLASGOW-TALBOT GAS POOL

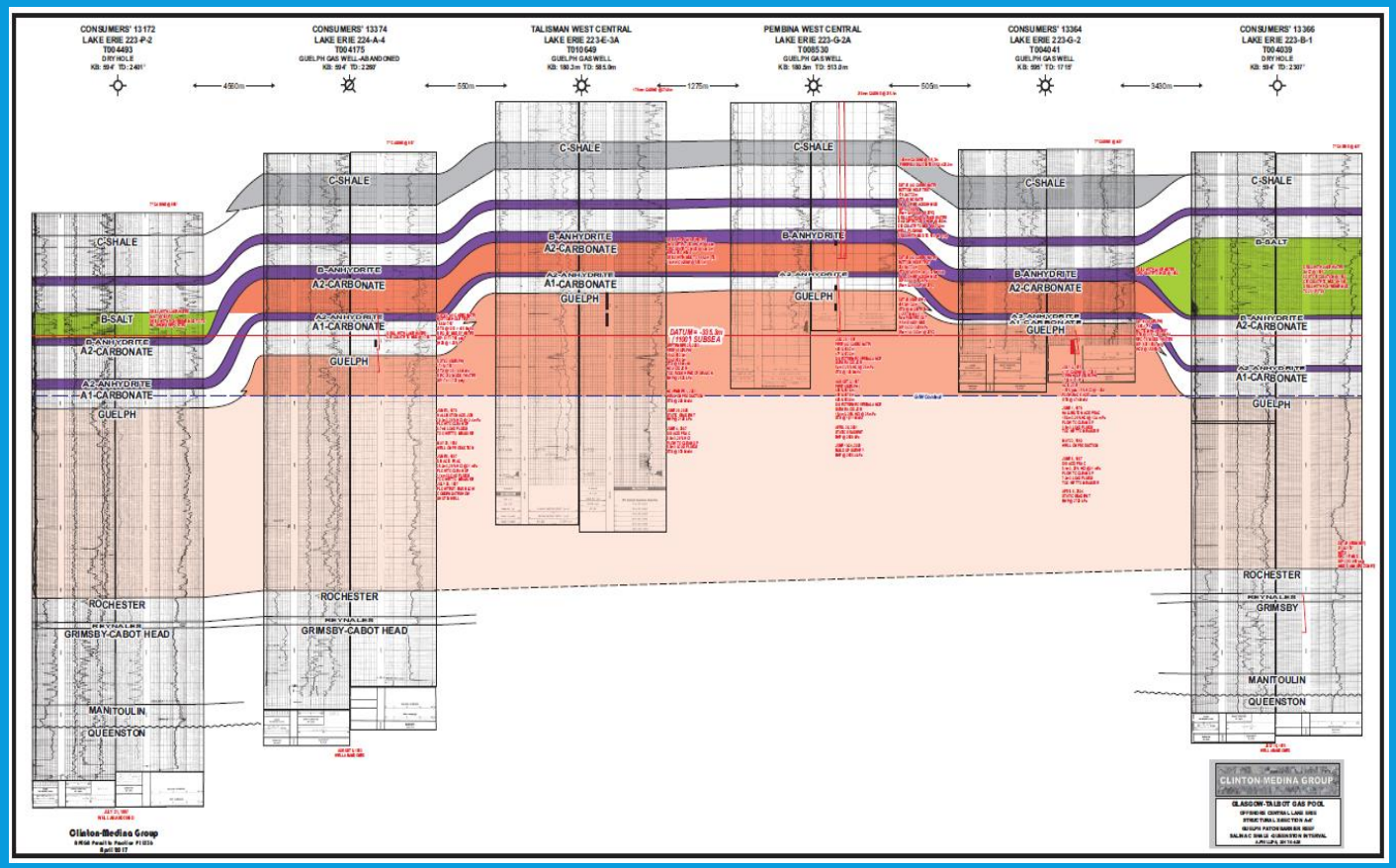


GLASGOW-TALBOT GAS POOL, CENTRAL LAKE ERIE

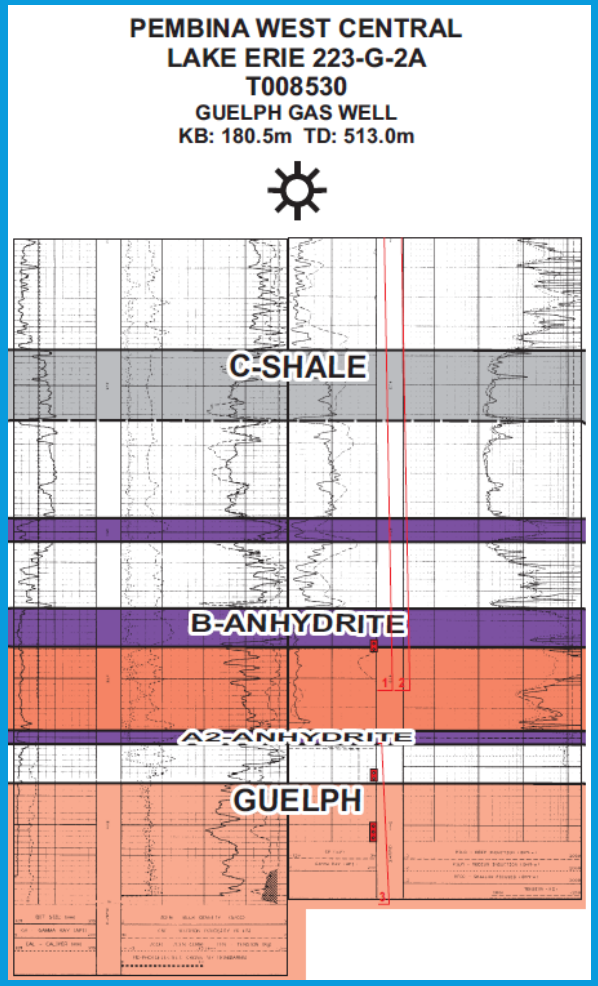


Total Guelph A1 Carbonate build up > 170m (558').

Regional thickness = 100m (328')

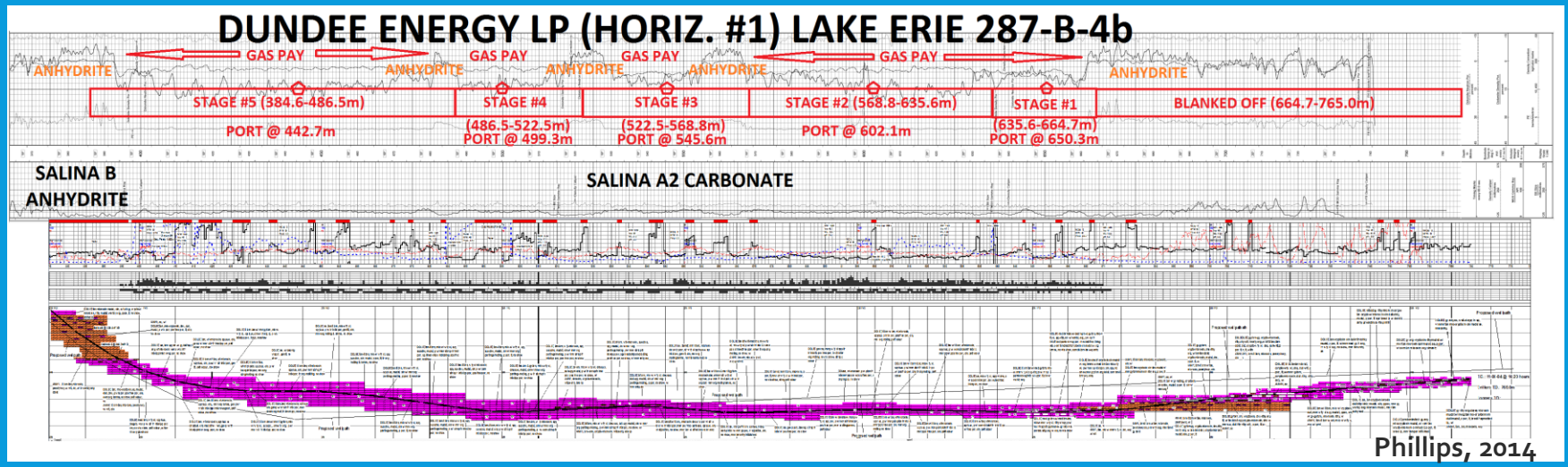


GLASGOW-TALBOT GAS POOL UPSIDE UPHOLE IN A2 CARBONATE



- Infill gas well drilled in 1997. Gas show @ 469m (1539') in Salina A2 Carbonate section.
- DST #2 flowed gas at 4,885 m3/d (172 Mcf/d), SIP = 4502 kPa (653 psig)
- Guelph reef section below is the better reservoir ,testing gas at 44,098 m3/d (1557 Mcf/d), was partially depleted SIP = 3438 kPa (499 psig)

HORIZONTAL DRILLING
A2 CARBONATE RESERVOIR



Offshore Tilbury Pool, Lake Erie 287-B-4b

Drilled 328m (1076') of horizontal section

5 stages acidized with 7-20 m3 (45-60 bbls)

Flow to cleanup at 8,496 m3/d (300 Mcf/d)

GUELPH PINNACLE AND INCIPIENT REEFS

Buildups moving deeper in the Michigan Basin.

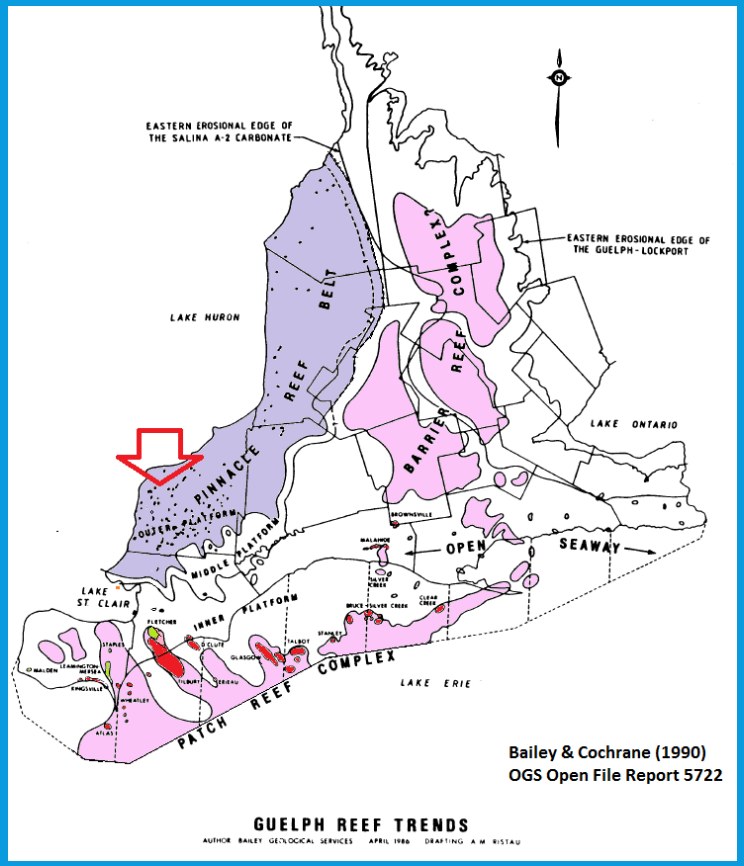
Oil Springs incipient (1914), Dawn 47-49 pinnacle (1930)

wildcat drilling, well witching, divining, shallow structure mapping

Kimball-Colinville, Payne, Corunna, Moore 3-21-XII (1947-1977)

shallow structure mapping ,gravity, seismic

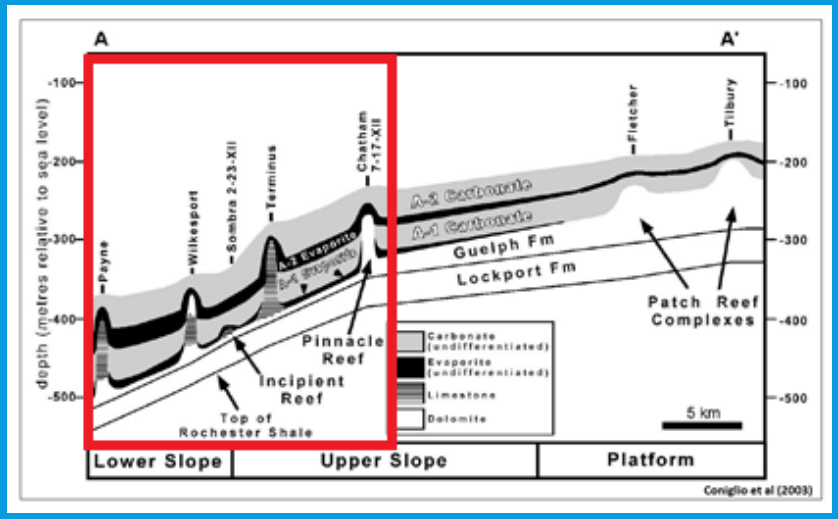
GUELPH PINNACLE-INCIPIENT REEFS LAMBTON & HURON COUNTIES



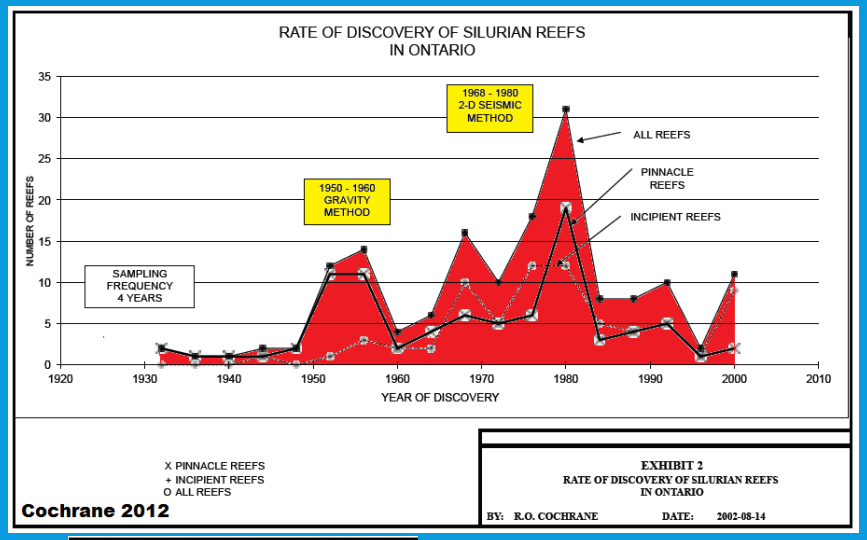
Bailey & Cochrane (1990)
OGS Open File Report 5722

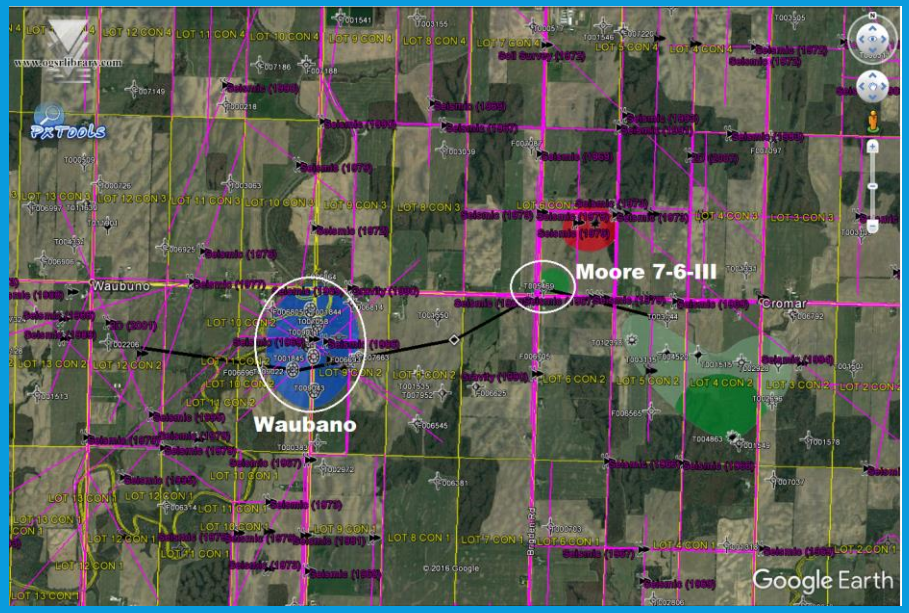
Pinnacle Reef Belt is basinward from the Patch-Barrier Complex that rims the Michigan Basin.

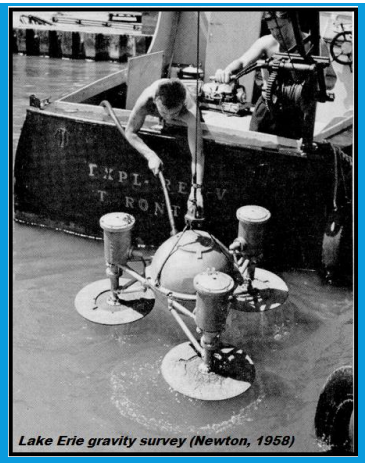
Oil and gas pools in these discrete reefs can be prolific, but the upside is in the reservoir can be reused as a gas storage pool.



RATE OF DISCOVERY OF SILURIAN REEFS IN ONTARIO



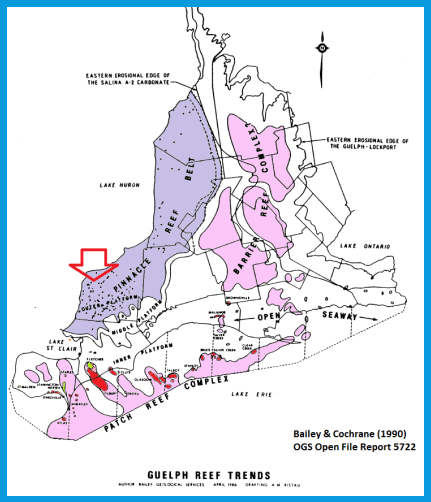



Lake Erie gravity survey (Newton, 1958)

1950-1960: Gravity Method, looking for salt thinning

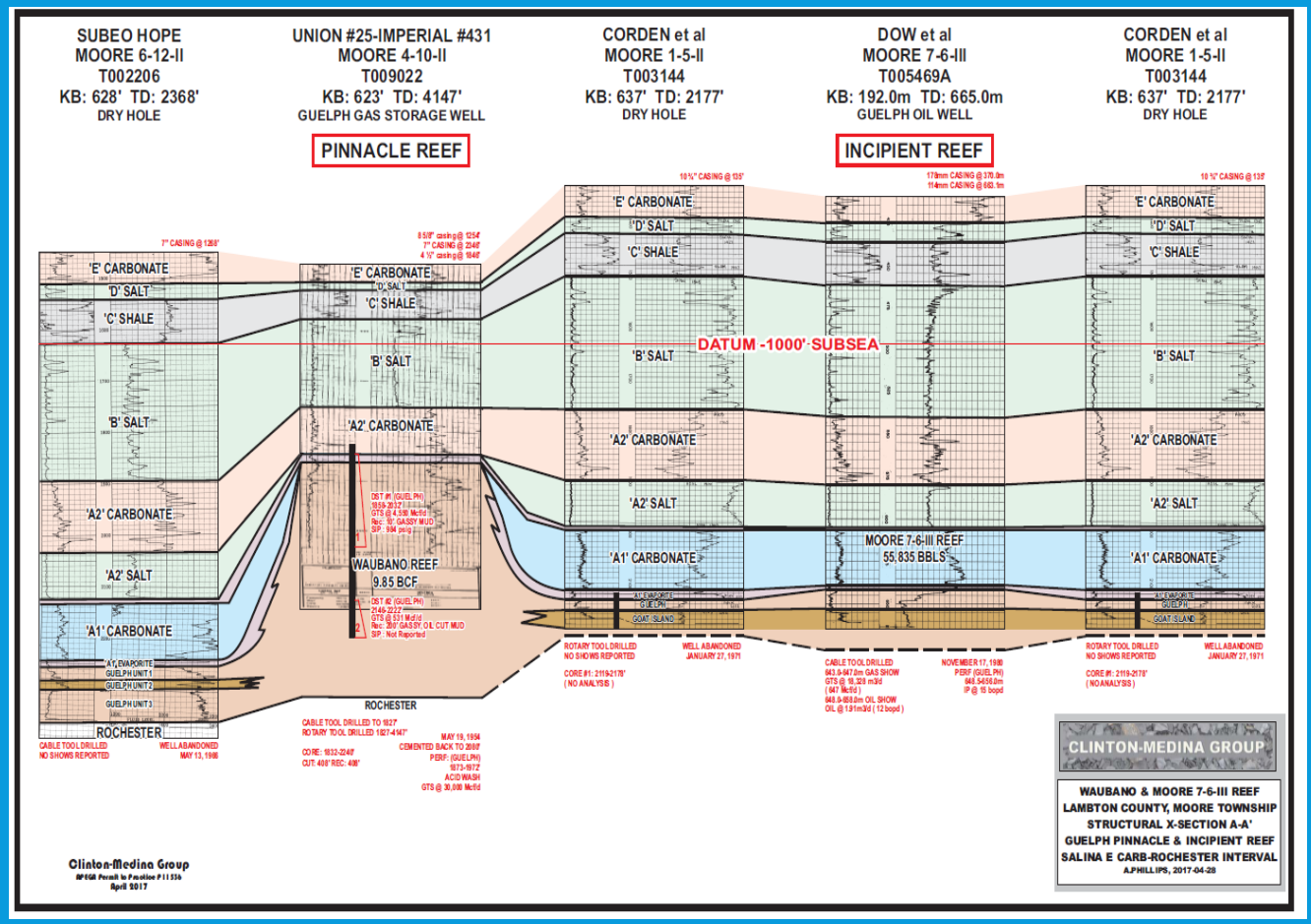
1968-1980: 2D Seismic Method, looking for reef buildups

PINNACLE & INCIPIENT REEF WAUBANO & DOW MOORE 7-6-III

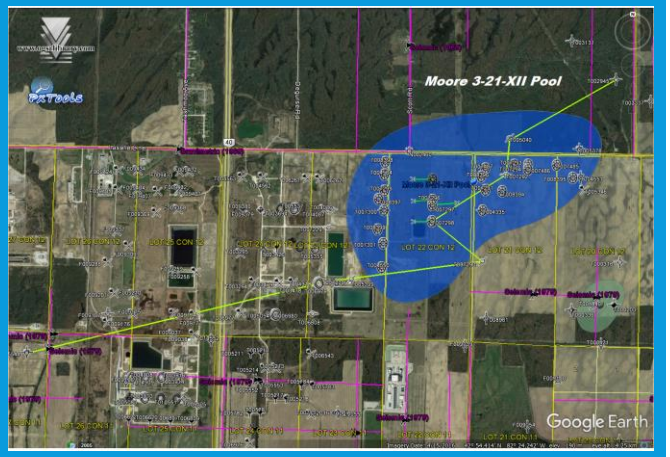


Waubano Pinnacle Reef 450' (137.2m), 9.85 Bcf Gas

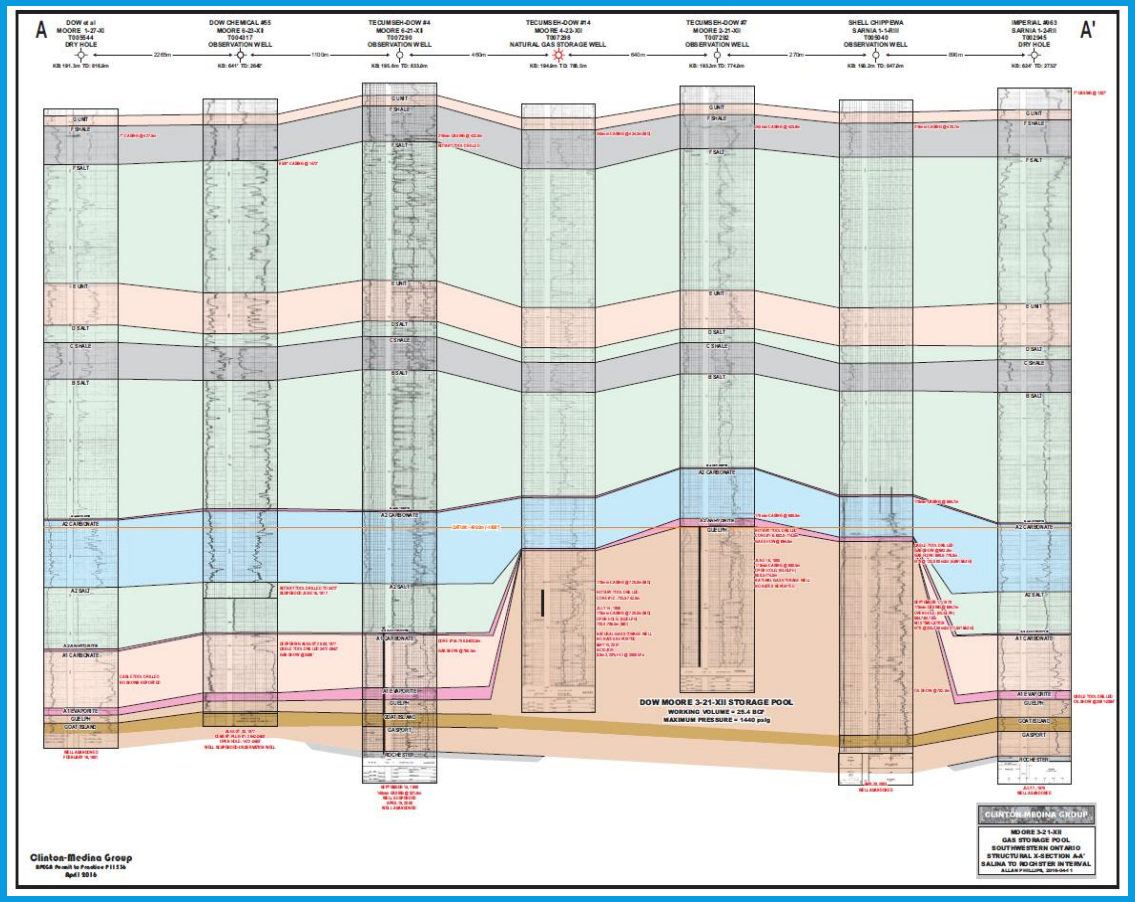
Moore 7-6-III Incipient Reef 120' (36.6m), 55,835 bbls Oil



GAS STORAGE RESERVOIR MOORE 3-21-XII

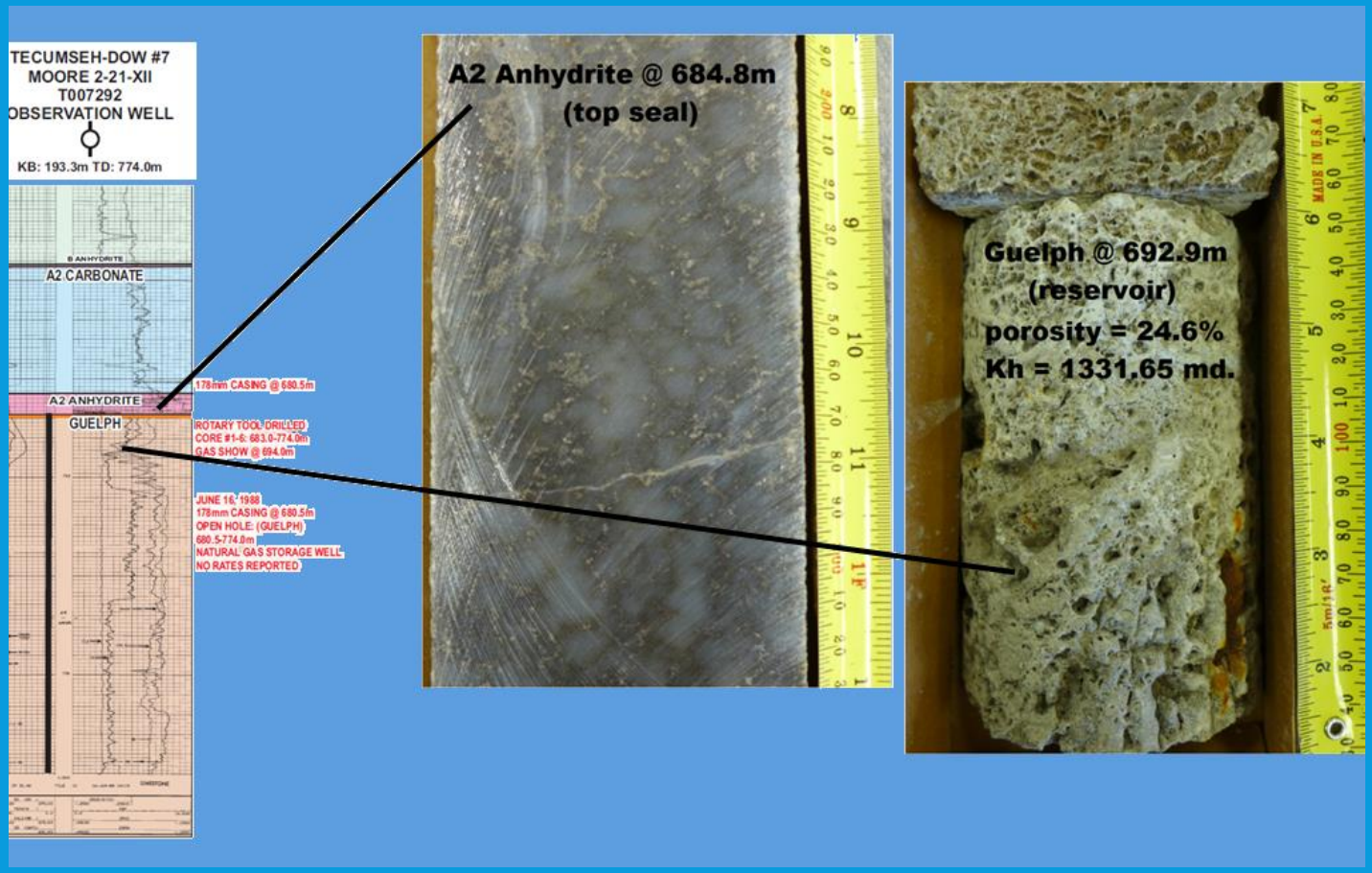


Discovery well Dow Moore 3-21-XII drilled in June 1977, flowed GTS @ 31 MMcf/d (877,920 m3/d) from a depth of 2471' (753.2m)

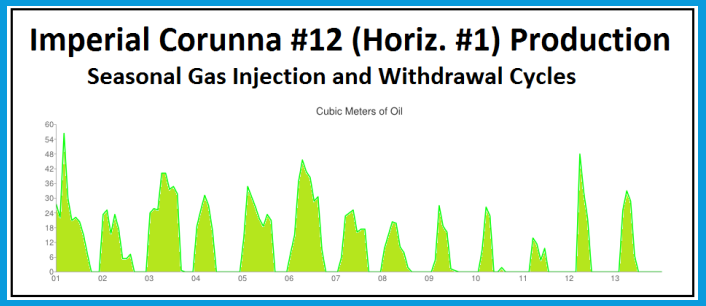


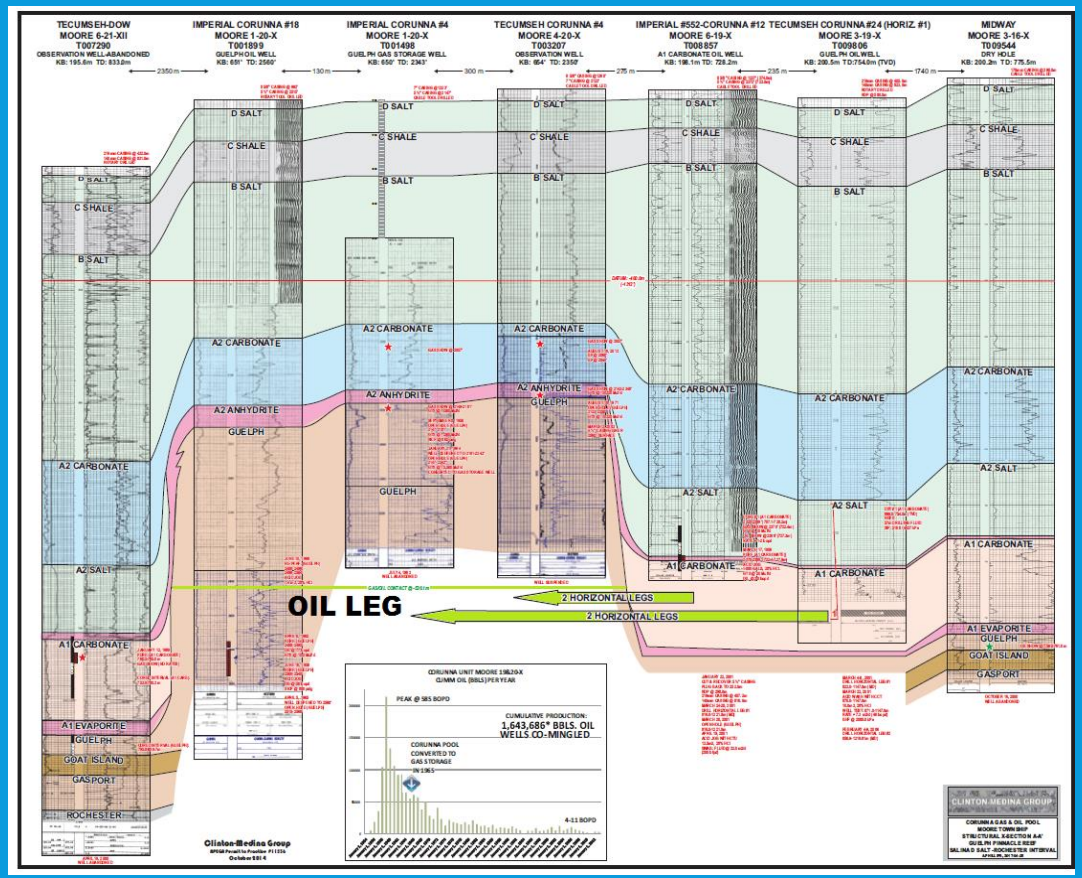
GAS STORAGE RESERVOIR ATTRIBUTES

Excellent limestone reservoir sealed with a cap of impermeable anhydrite



CORUNNA GAS STORAGE POOL OIL LEG EOR WITH GAS INJECTION





GUELPH AND SALINA STRUCTURAL POOLS

Oil & gas pools along fault trends.

Dawn , Chatham-Dresden-Camden Gore, Zone (1914-1943)

wildcat drilling, well witching, divining, trendology

Becher East, Becher West (1946)

shallow structure mapping , trendology

GUELPH-SALINA STRUCTURAL OIL AND GAS TRAPS (BECHER WEST)

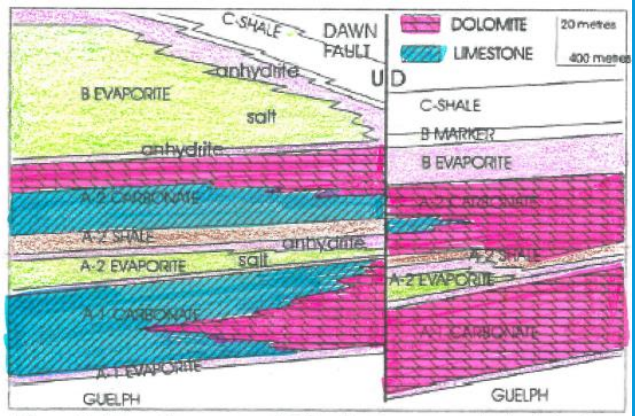
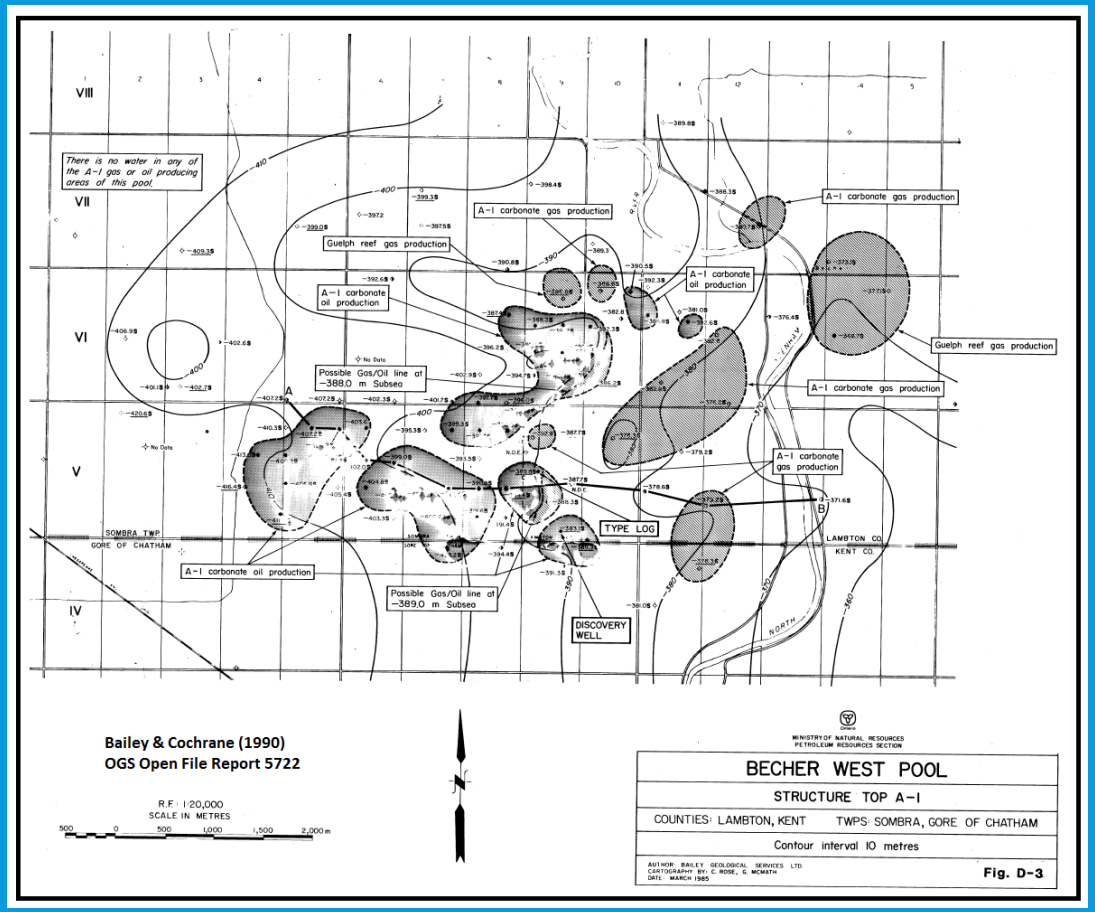


Figure 8. Schematic summary of dolomitization patterns in the A-1 and A-2 Carbonate Units near the Dawn Fault in Sombra Township, Lambton County, in southwestern Ontario. Modified from Carter (1991).

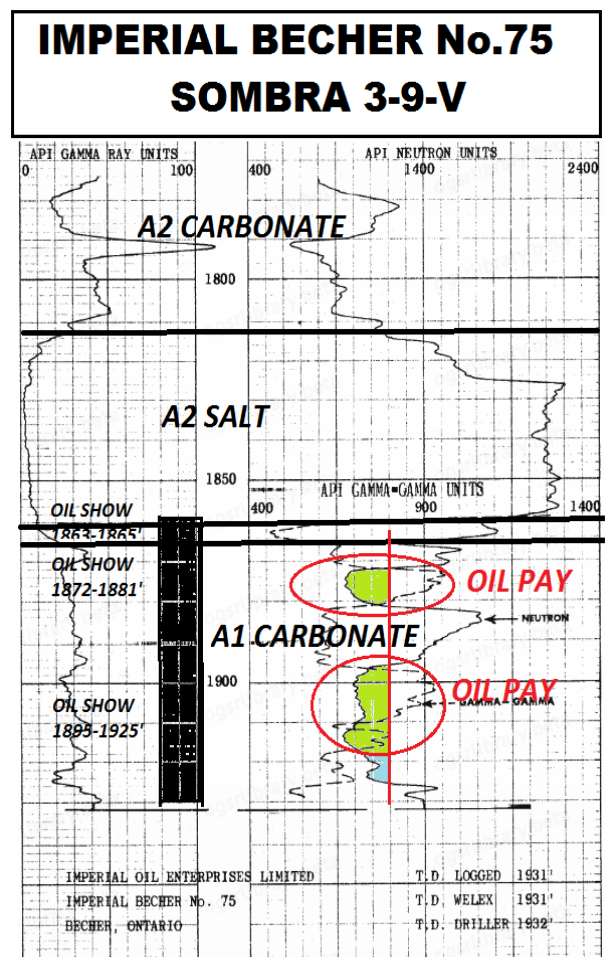
Carter et al (1994)

Discovery well in Becher West Pool, Imperial #15 Sombra 8-9-V completed in February 1946 produced oil at 15 bopd from the Salina A1 Carbonate at 1844' (562.1m)



BECHER WEST OIL POOL
2,679,842 BBLS RECOVERABLE

Very good porosity with fair permeability in this very fine grained dolomite with 36.0°API oil was converted to water flood in 1964

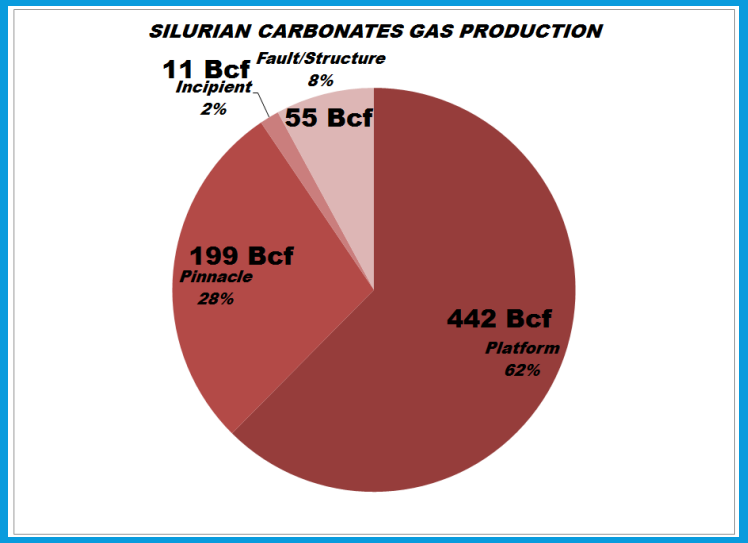


IMPERIAL BECHER #75
SOMBRA 3-9-V
UPPER POROUS RESERVOIR
OIL STAINED DOLOMITE
POROSITY = 18.7%
PERMEABILITY = 33.0md

WHERE DO WE GO FROM HERE?

Looking at the historical production can we predict where to go looking for more production from these reservoirs?

TABULATION OF NATURAL GAS TRAPS IN SILURIAN CARBONATES



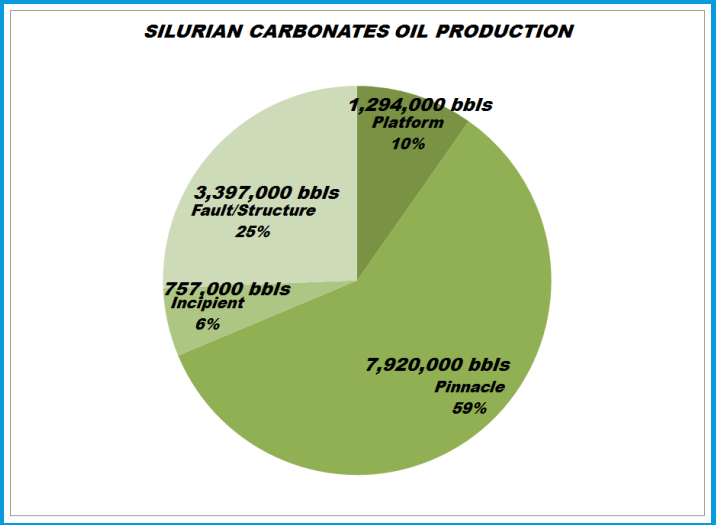
Tabulation of Hydrocarbon Traps in Silurian Carbonates of Southwestern Ontario

Trap Type	Gas Pools	Oil and Gas Pools	Oil Pools	Barren Traps	TOTAL POOLS	Gas Storage Pools	Cumulative Production to end 1999 Metric Units Gas million m3	Metric Units Oil 1,000m3	Imperial Units Gas bcf	Imperial Units Oil 1,000 bcf	Examples
A) Stratographic Traps											
A.1) Reefs											
A.1a) Platform Reefs	13	4	5	6	28	0	12,456	206	442	1,294	Tilbury, Fletcher
Includes 5 production units in Lake Erie											Morpeth and Silver Creek Units
Pinnacle Reefs	31	14	7	34	86	28	5,613	1,259	199	7,920	Kimball-Colinville, Dawn 156, Bickford, Corunna, Seckerton, Grand Bend, Warwick
Incipient Reefs	16	15	17	27	75	1	302	120	11	757	Otter Creek, Betch East, Dawn 28-II, Sombra 4-16-IX, Cromar
SUBTOTAL	60	33	29	67	189	29	18,371	1,585	652	9,971	
A.2) Facies Control	1	1	0	0	2	0	19	0	1	2	Moore 50-50-Front, Camden Gore 6-10-IX
TOTAL STRATOGRAPHIC	61	34	29	67	191	29	18,390	1,585	653	9,973	
B) Structural Traps											
B-1) Fault-related Traps	6	6	1	1	14	***	1,158	534	41	3,356	Zone, Chatham Brigden, Camden Gore, Becher West
B-2) Anticlinal Traps	1	5	2	1	9	0	237	6	8	39	Townline, Mosald
B-3) Salt Dissolution	2	1	0	0	3	0	181	0	6	2	Morpeth
TOTAL STRUCTURAL	9	12	3	2	26	0	1,576	540	55	3,397	
TOTAL	70	46	32	69	217	29	19,966	2,125	708	13,370	

Cochrane, 2004

708 Bcf (19,966 million m3) of gas production to Q4/1999. Majority of the gas production (62%) is from platform reefs on the up dip margin of the basin. Moving basinward, pinnacle reefs account for next highest percentage (28%) and incipient reefs for 2%. Structural Guelph/Salina traps make up the balance (8%).

TABULATION OF OIL TRAPS IN SILURIAN CARBONATES



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TOTAL STRUCTURAL	9	12	3	2	26	0	1,576	540	55	3,397	
TOTAL	70	46	32	69	217	29	19,966	2,125	708	13,370	

Cochrane, 2004

13,370,000 bbls (2,125,000 m3) of oil production to Q4/1999. Majority of the oil production (59%) is from pinnacle reefs deeper in the basin. Structural Guelph/Salina traps account for next highest percentage (25%) and incipient reefs for 6%. Platform reefs (Fletcher Pool) make up the balance (10%).

OIL & GAS IN SILURIAN CARBONATES OF THE GUELPH AND LOWER SALINA

- Historical production from these shallow Silurian carbonate pools in southwestern Ontario on the southeastern rim of the Michigan Basin have had a long and storied history.
- Some of these prolific reservoirs are being reused as natural gas storage pools in the second largest storage hub in North America.
- Exploration for smaller lower productivity gas reservoirs is faced with challenging economics with low gas prices and higher risk.
- Economics for oil is more favorable, therefore focus should be on exploration and development of onshore oil prospects.
- Exploration for Salina and Guelph structures, incipient reefs and enhanced oil recovery in existing Guelph reef and structural oil pools should be the focus in this current economic environment.

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