Bedded Salt in Ontario: Geology, Solution Mining and Cavern Storage

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Saskatchewan
Alberta
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Ontario
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Newfoundland
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Nova Scotia
Maine
Montana
North Dakota
Mich.
New York
Pennsylvania
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Utah
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Texas
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Sonora
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MAJOR SALT DEPOSITS
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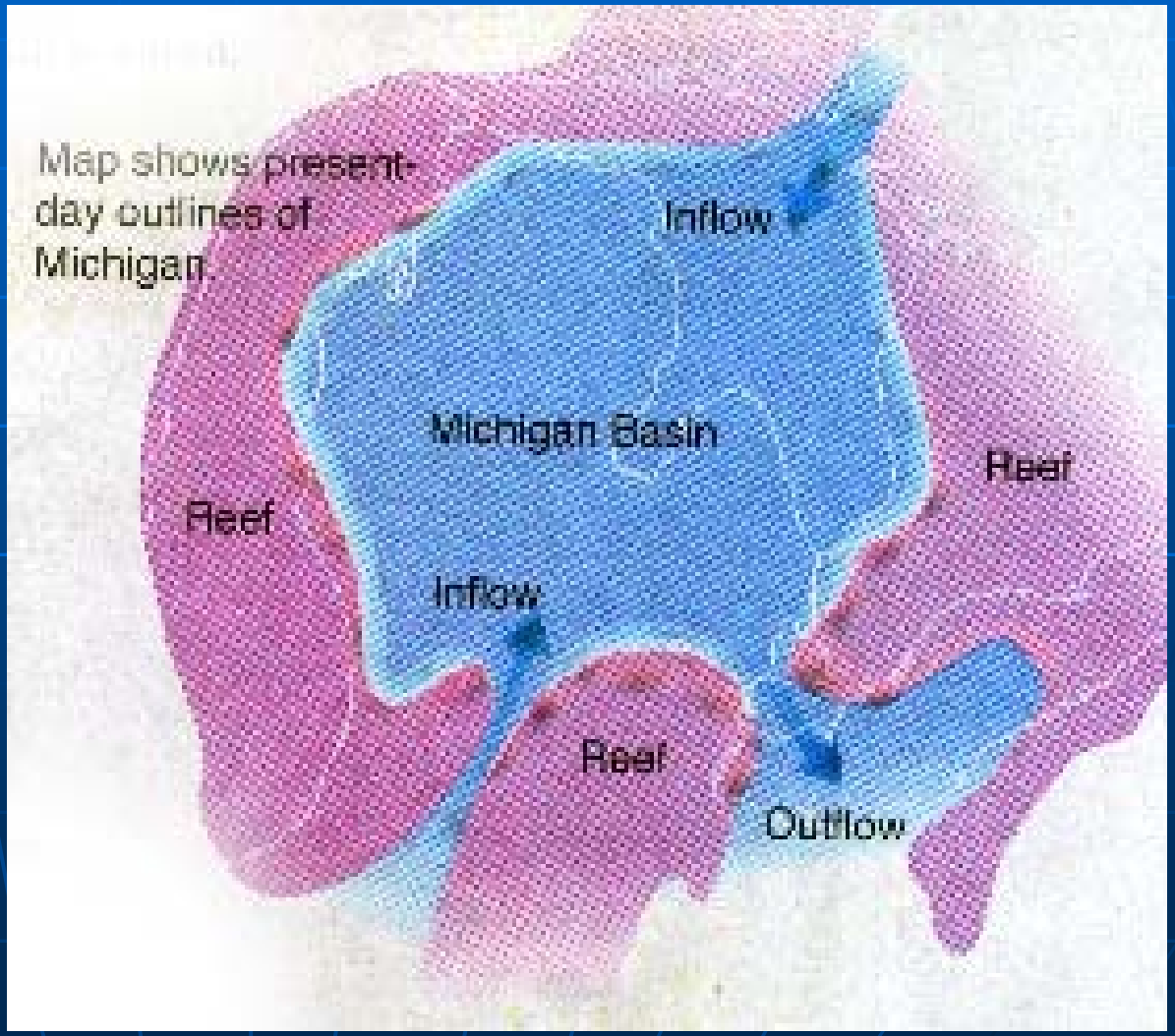
Salt basin

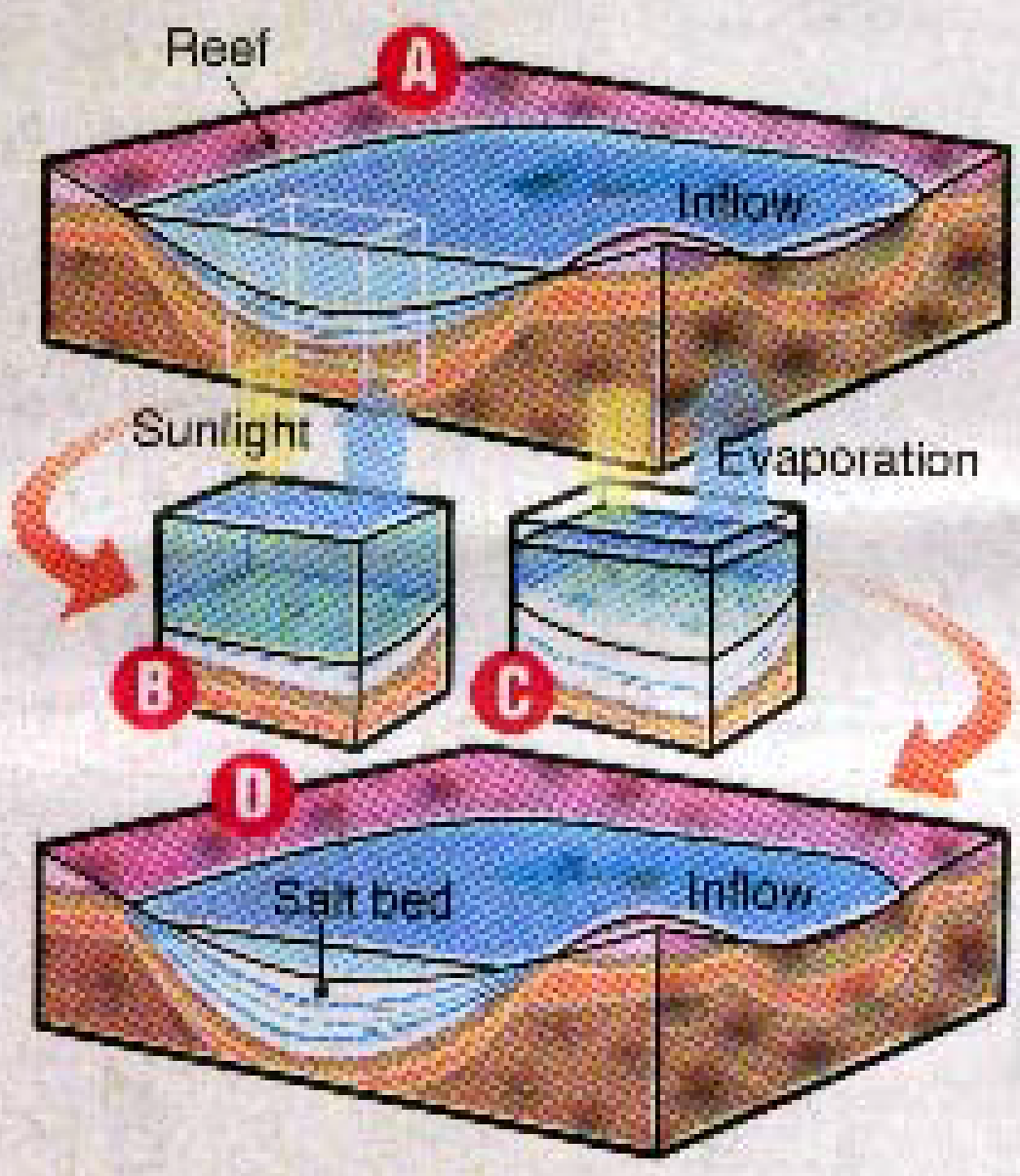
-Shallow inland sea

-Restricted outlets to ocean

-Arid climate

-30 degrees south of equator





Salt cycle

These cross-sections (at left) show the cycle that built up Michigan's salt beds:

A Reefs surrounding a shallow basin restrict the flow of sea water.

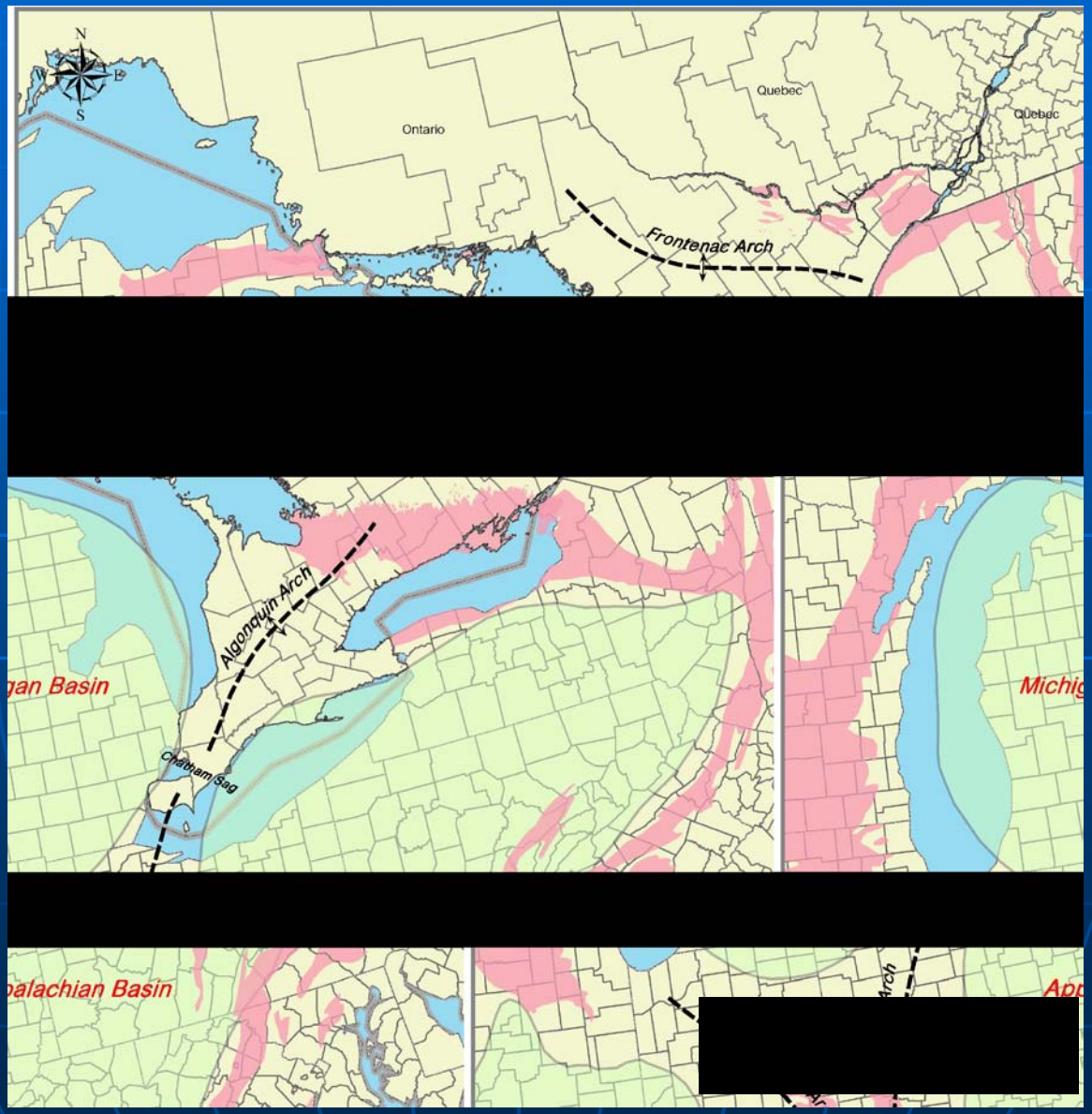
B Sunlight and warm temperatures cause the water to evaporate.

C Eventually, so much water evaporates that the remaining water can no longer hold the salt in solution. The salt begins to precipitate, falling to the sea bottom.

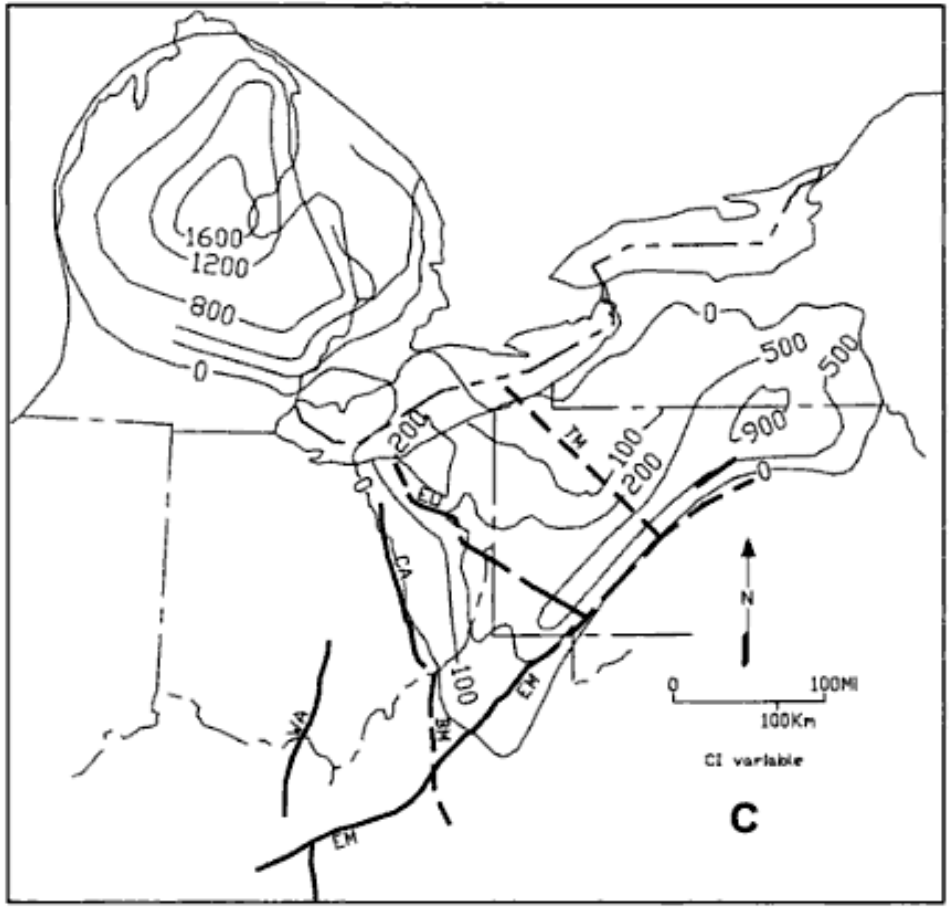
D More sea water flowing into the basin starts the cycle again.

Salt basin – Great Salt Lake

Sedimentary Basins

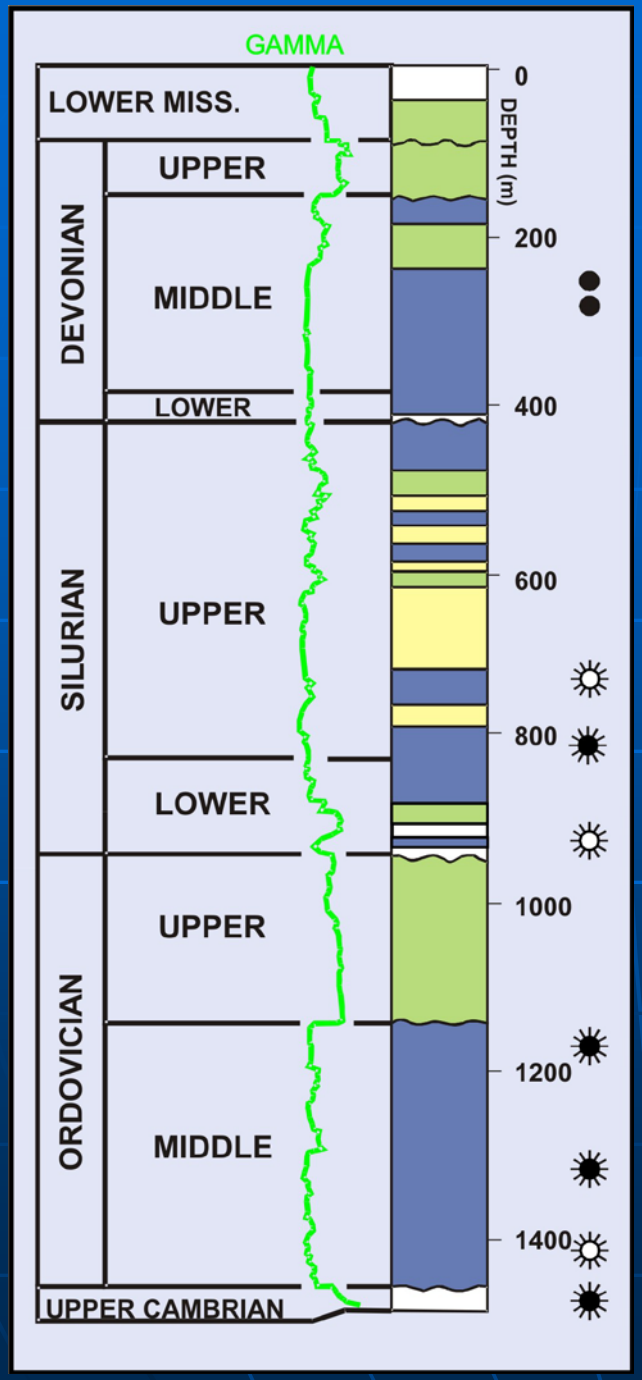


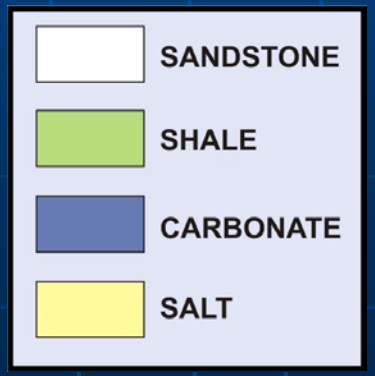
Salina Group Salt Isopach



in GSA Special Paper 308, 1996

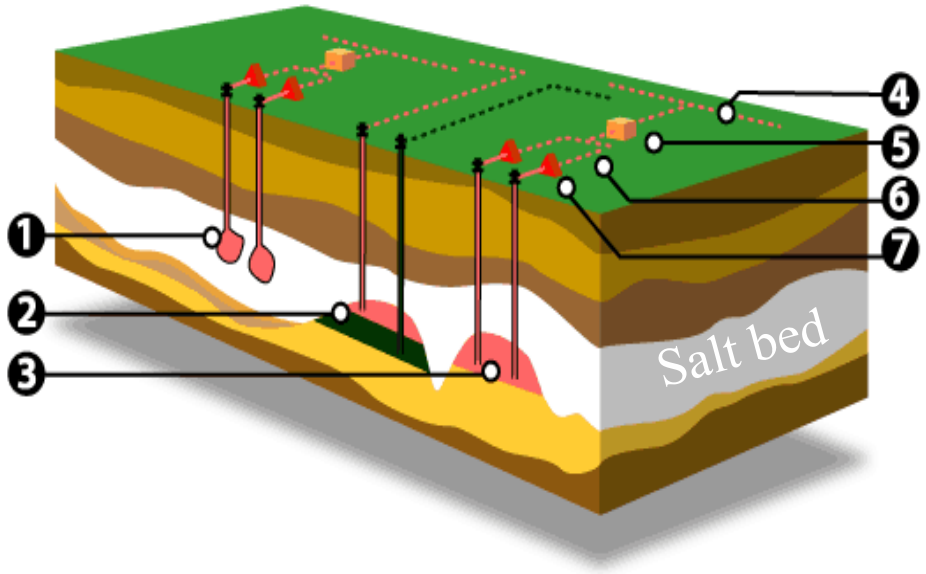
Stratigraphy, Oil, Gas and Salt in Ontario





Subsurface Resource Uses

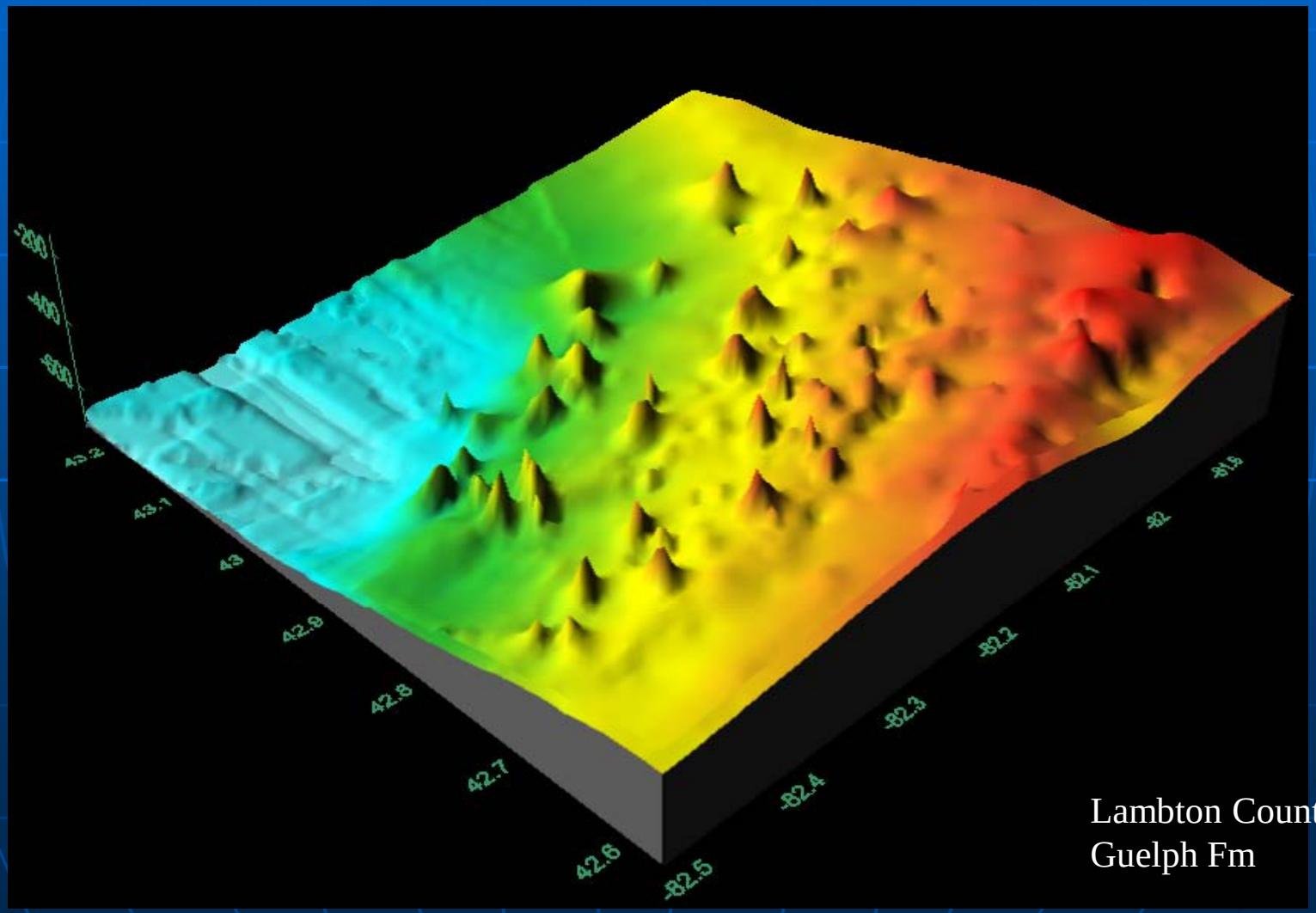
- Oil & Gas production
- Cavern storage
- Salt solution mining
- Natural gas storage



1. Salt cavern hydrocarbon storage
2. Oil & gas reservoir
3. Natural gas reservoir storage
4. Transmission pipeline
5. Compressor
6. Gathering pipeline
7. Emergency shut down valve

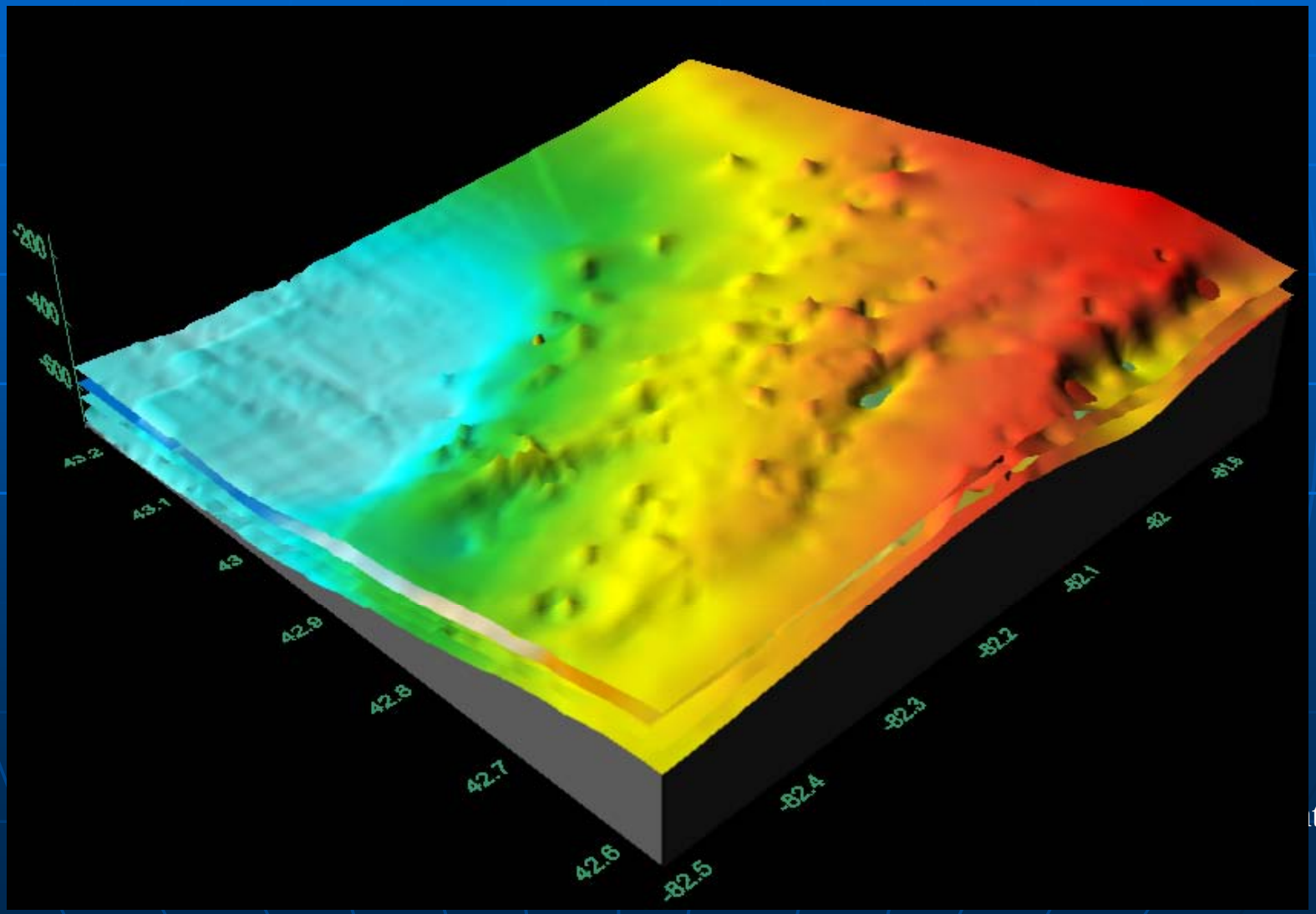
Pinnacle Reefs

oil & gas and gas storage



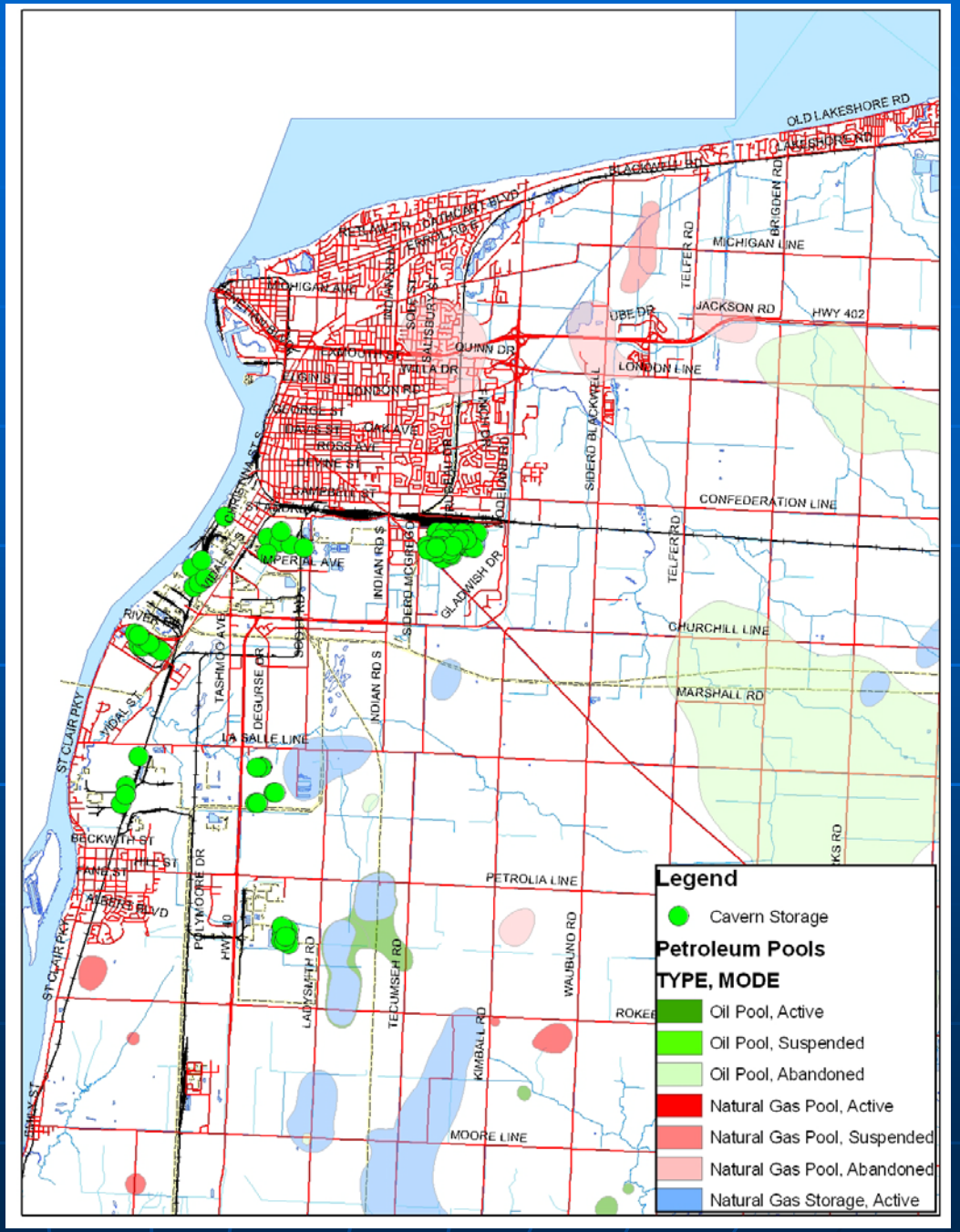
Lambton County – Guelph Fm

Burial of reefs by A-2 Salt and A-2 Carbonate limestone

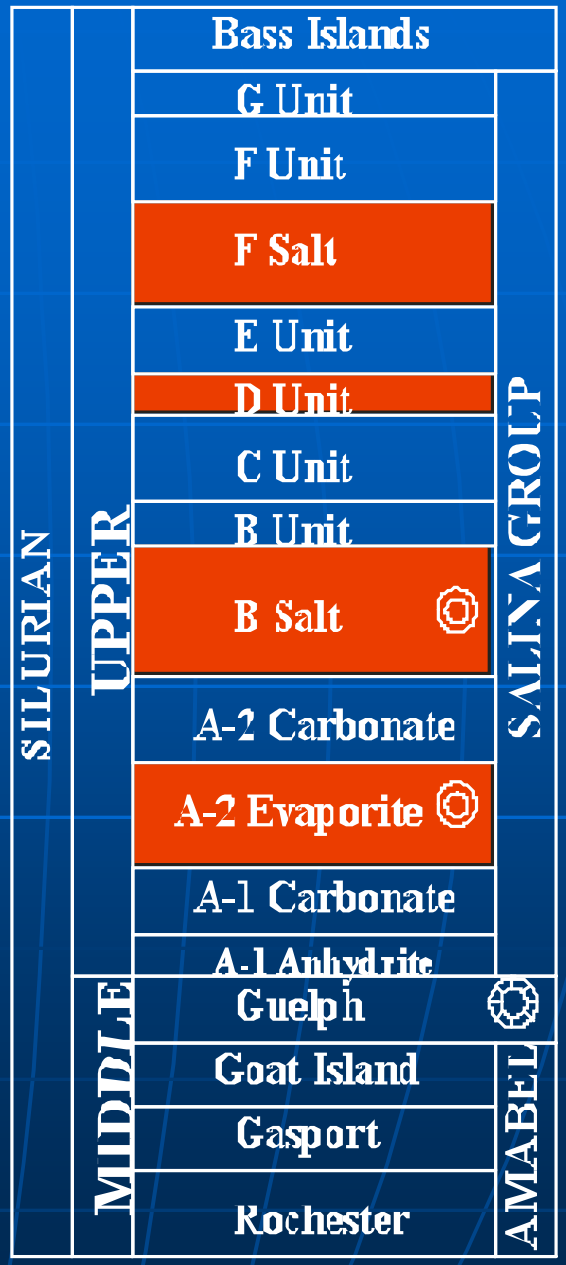


ty –
Fm

Oil, Gas, Gas Storage, Cavern Storage in Sarnia Area



Salina Group Stratigraphy



Salina F Unit

-Uppermost and shallowest salt beds, 275 – 450 m.
-Several separate beds with max combined thickness 90 m
- underground mining at Windsor

Salina D Unit

- thinnest salt in Ontario – 12 m max
- no mining

Salina B Unit

- thickest salt in Ontario – 90 m with numerous interbeds of dolomite and anhydrite

- 16,000 km^2

- solution mining Goderich, Windsor

- cavern storage Sarnia, Windsor

Salina A-2 Salt

-Lowermost and deepest salt bed in Ontario, 500 – 775 m.
-One bed up to 45 m.
- underground mining at Goderich
- cavern storage Sarnia

Bedded Salt

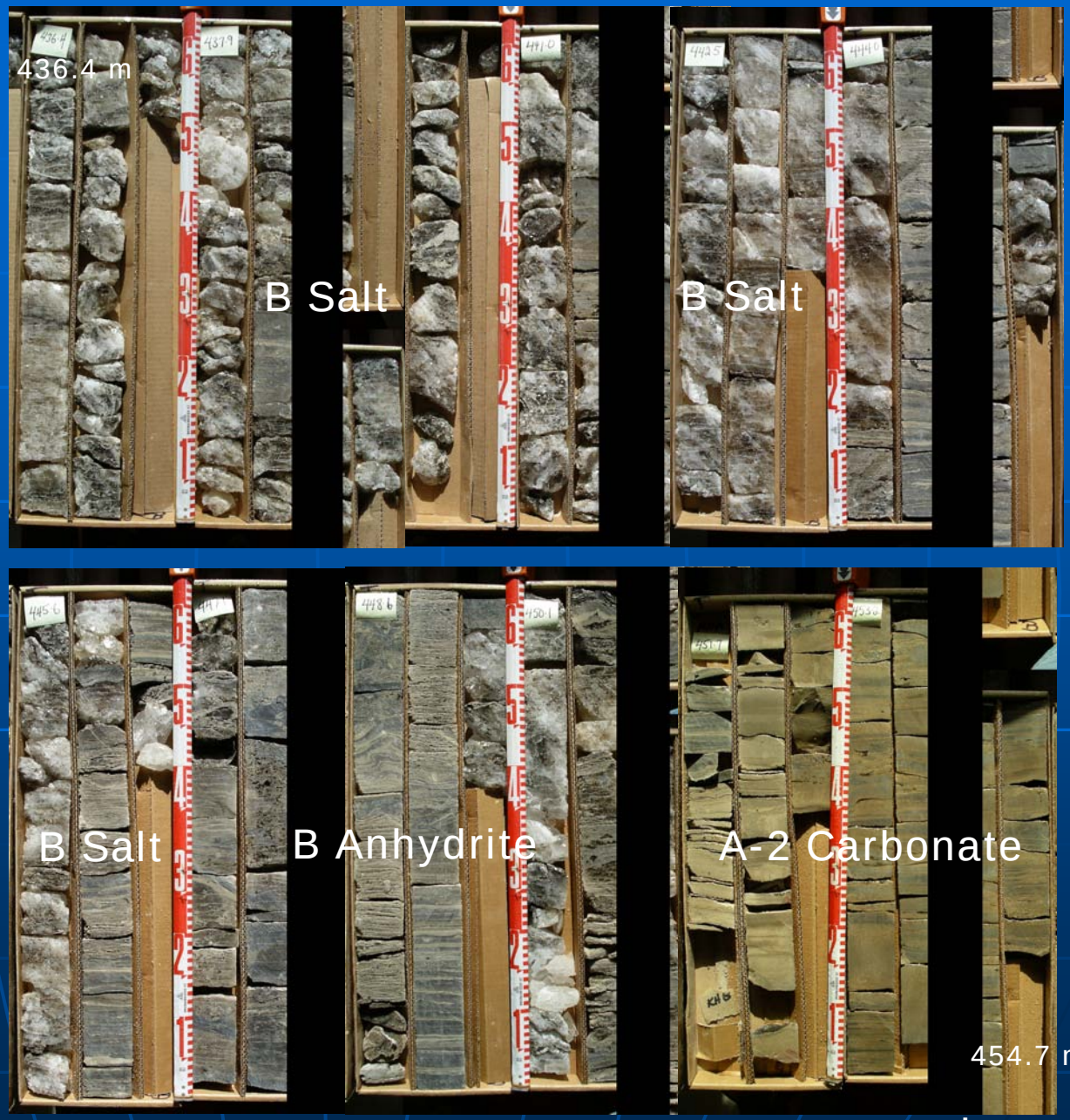
Non-salt Rocks

B Salt Lithology

OGS 82-2 Chatham

Harwich 1-25-IECR

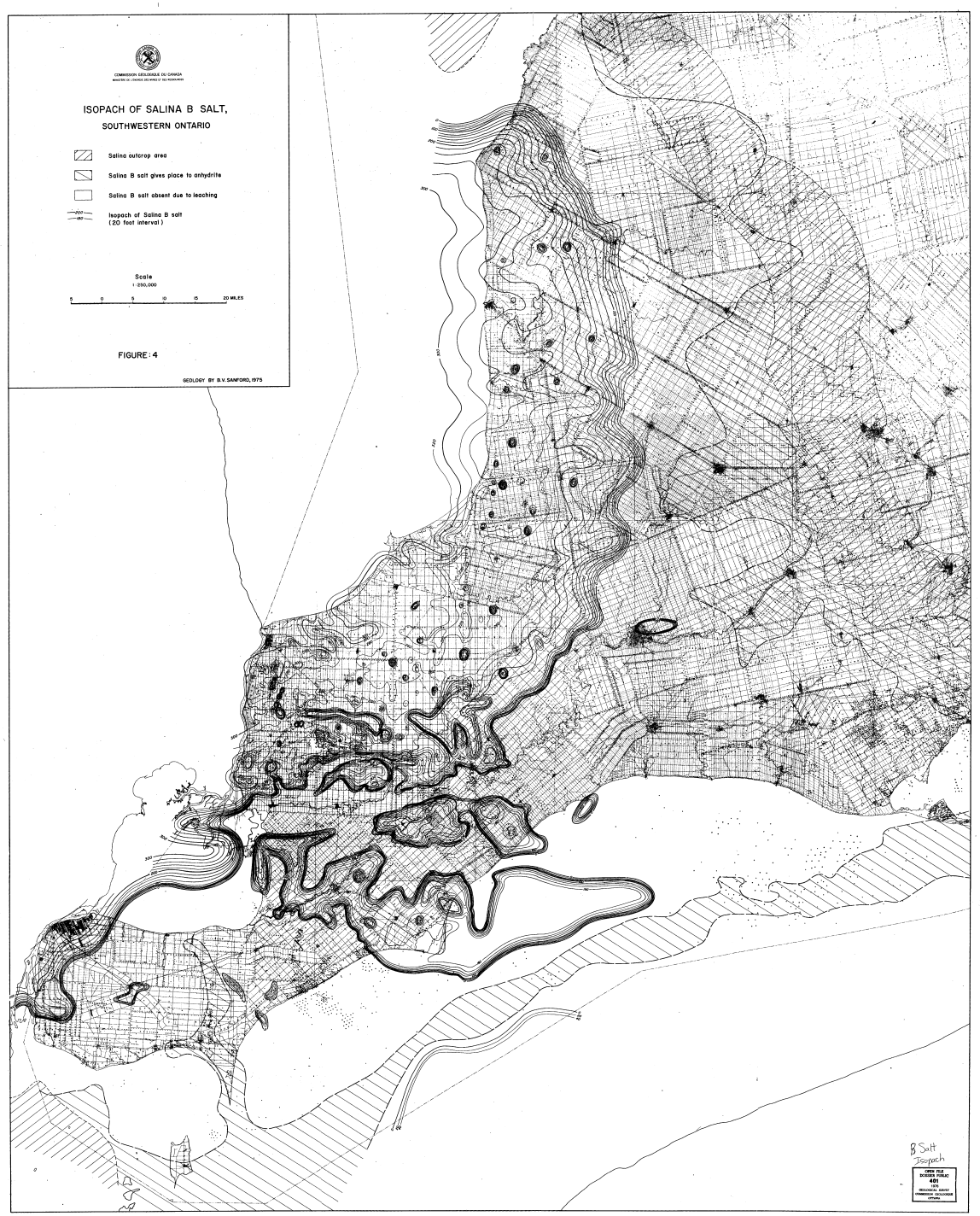
top



bottom

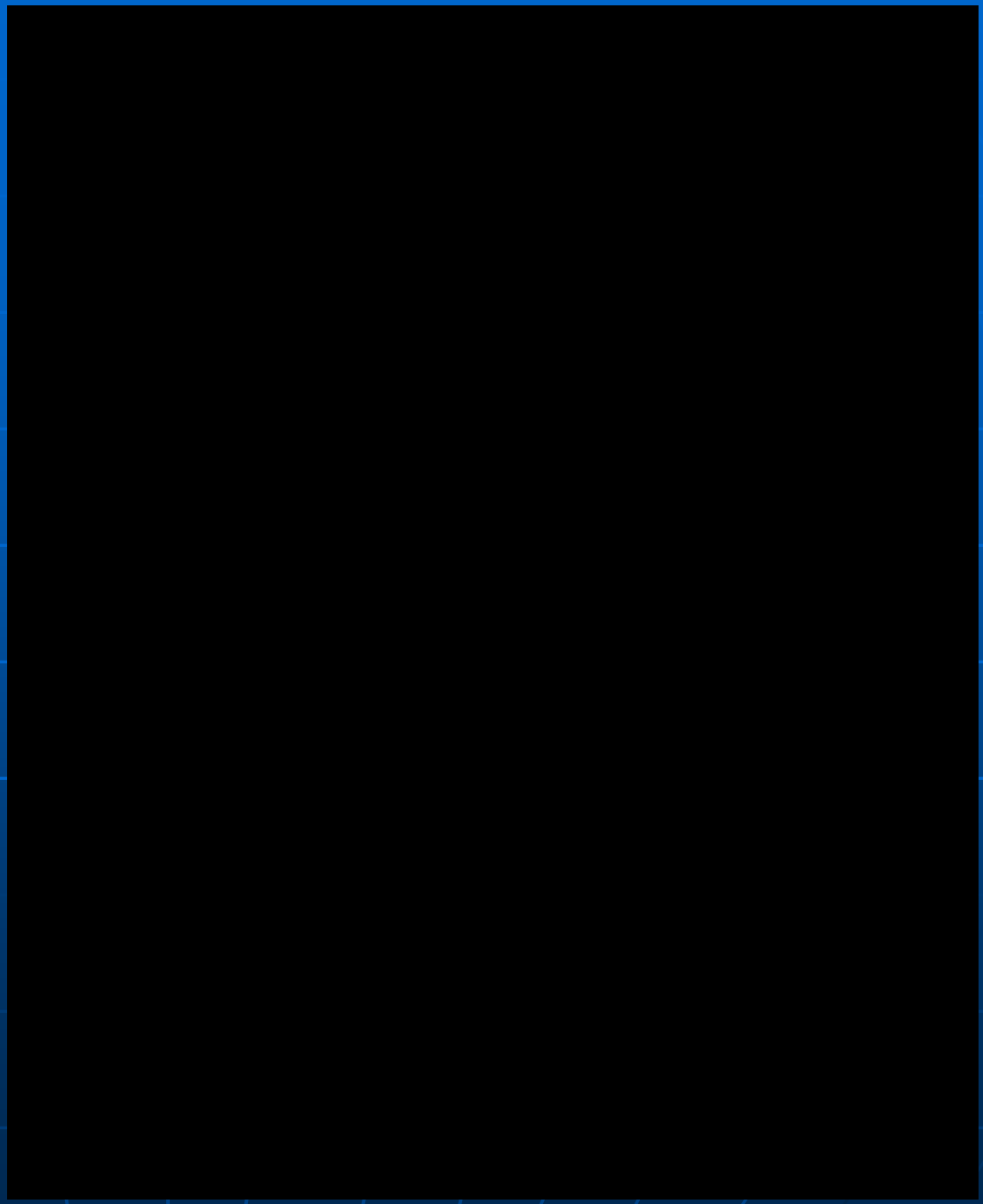
Salt Dissolution

- All Salina salt beds exhibit evidence of dissolution after deposition
- Timing variable
- B Salt: Eastern edge is dissolution front – thin from 30 m to zero in 1 km

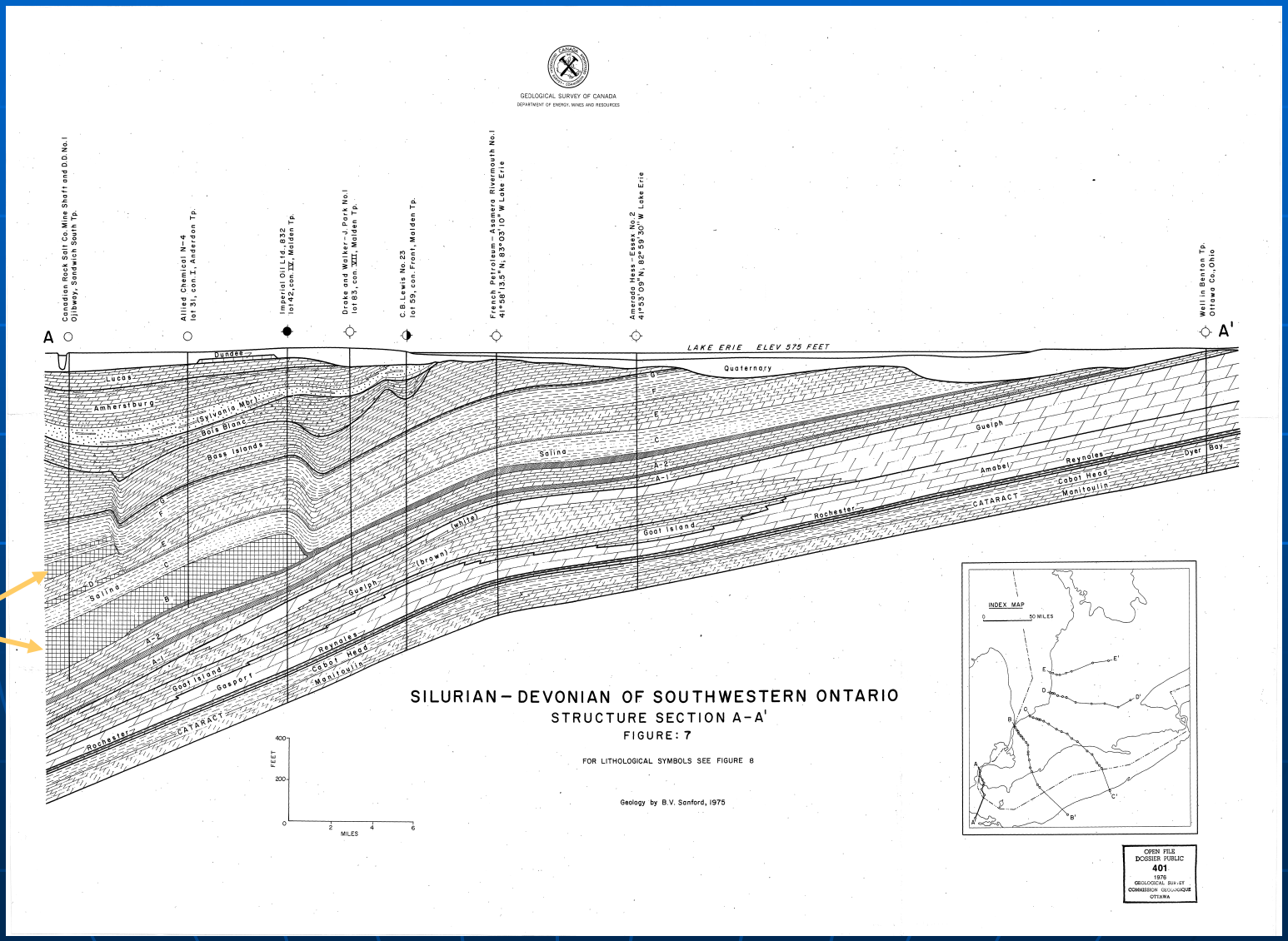


Salt Dissolution

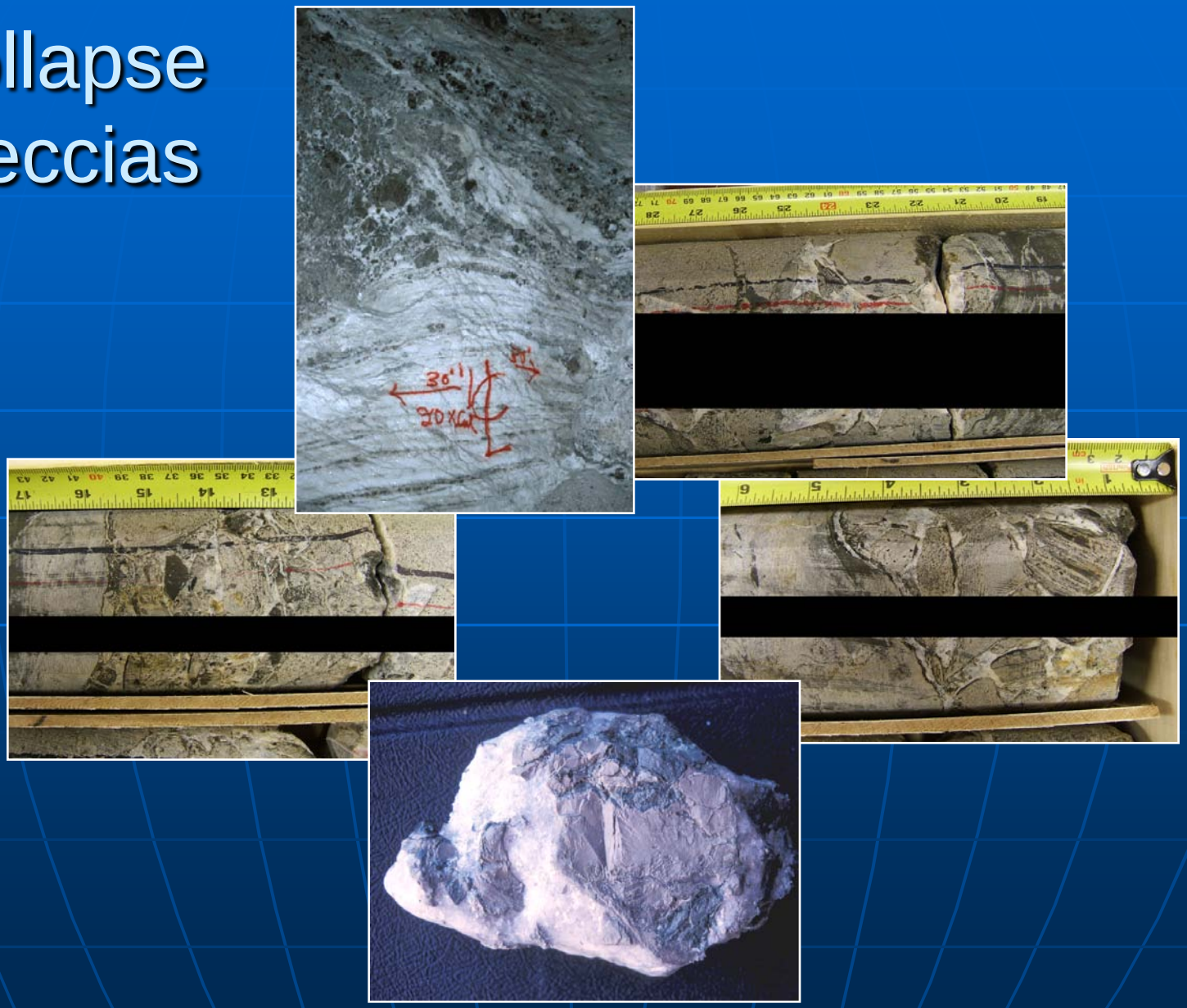
B Salt: Windsor area



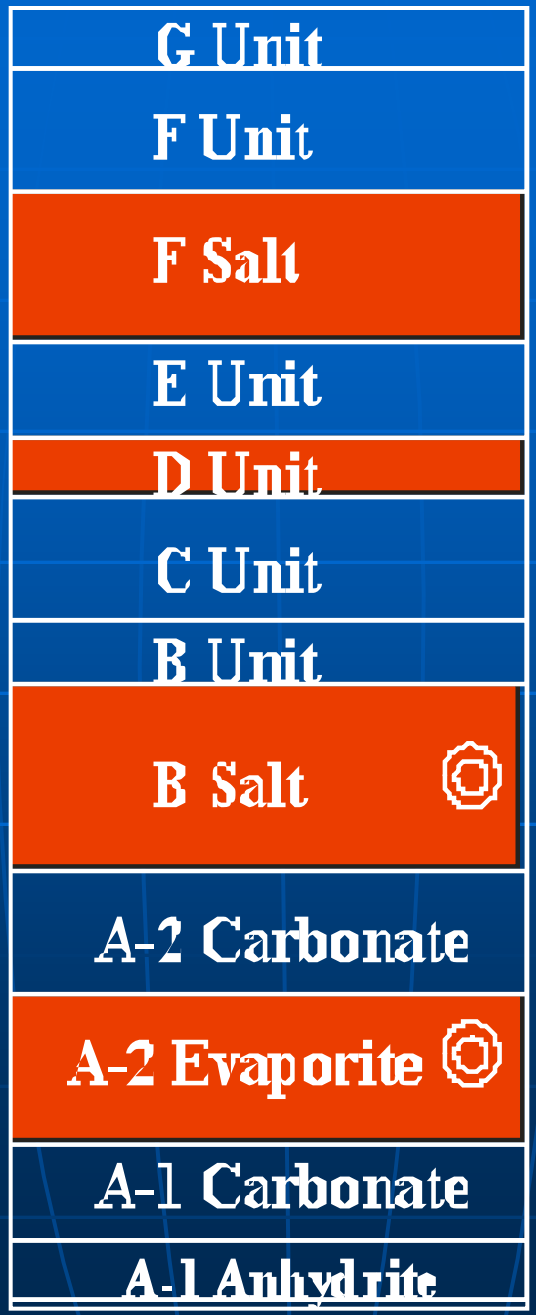
Salt Dissolution



Collapse breccias



Mining and Cavern Storage



Underground mining - Windsor

solution mining – Goderich, Windsor

Cavern storage - Sarnia

Underground mining – Goderich

Cavern storage - Sarnia

Solution Mining

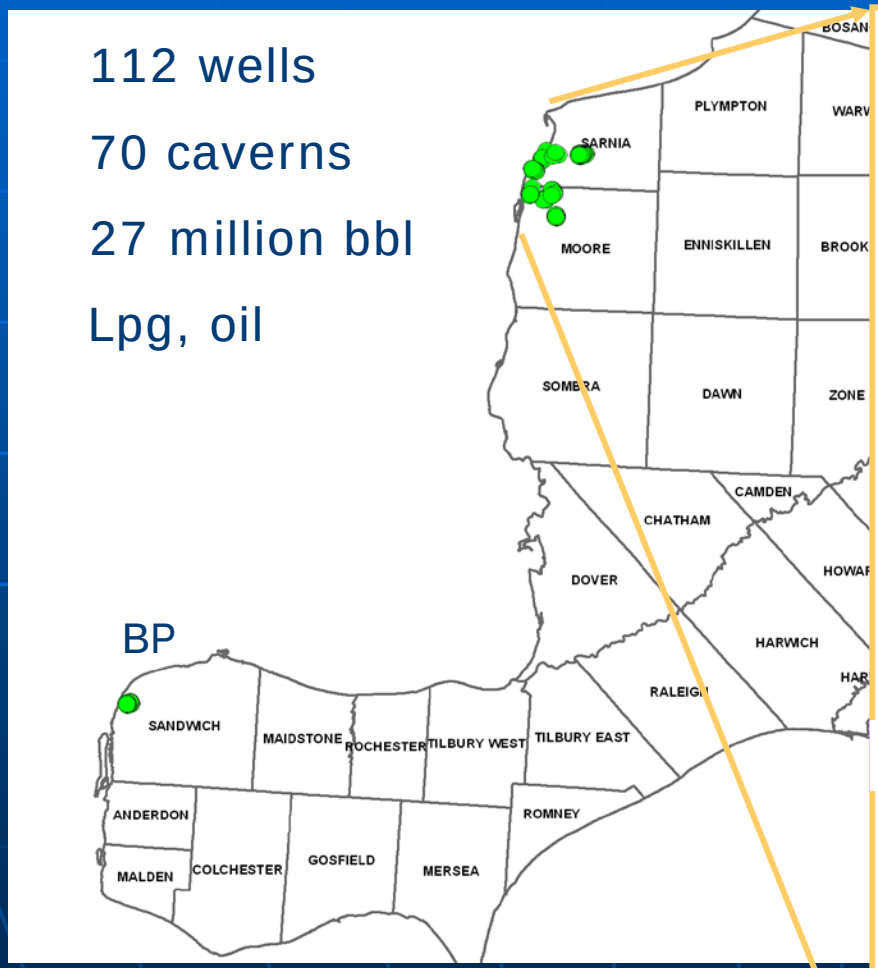
Cavern Storage in Ontario

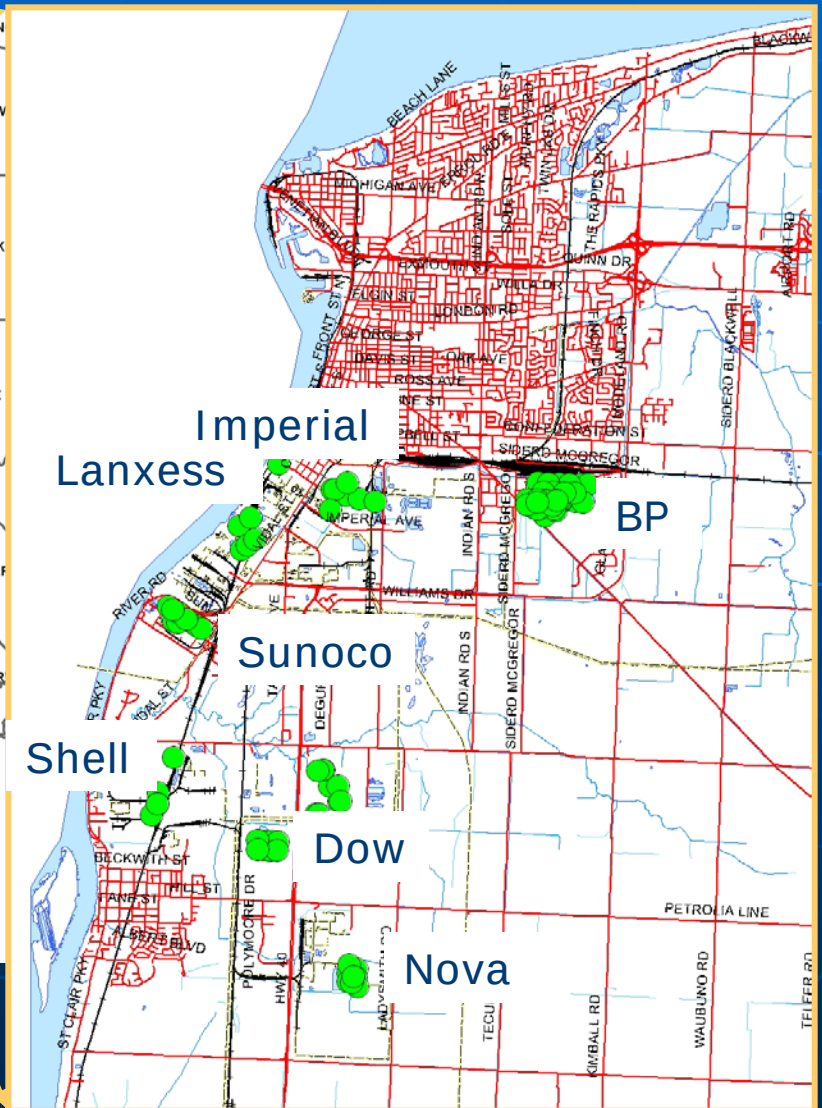
112 wells

70 caverns

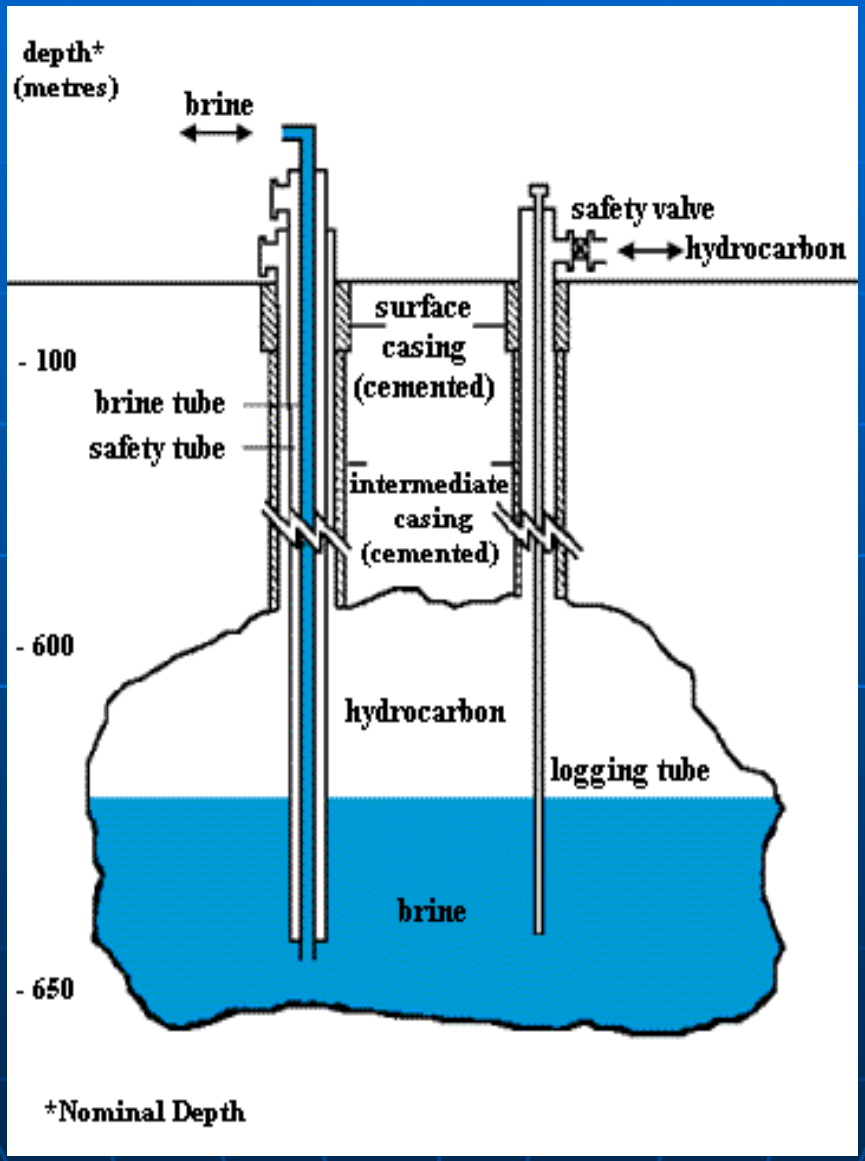
27 million bbl

Lpg, oil

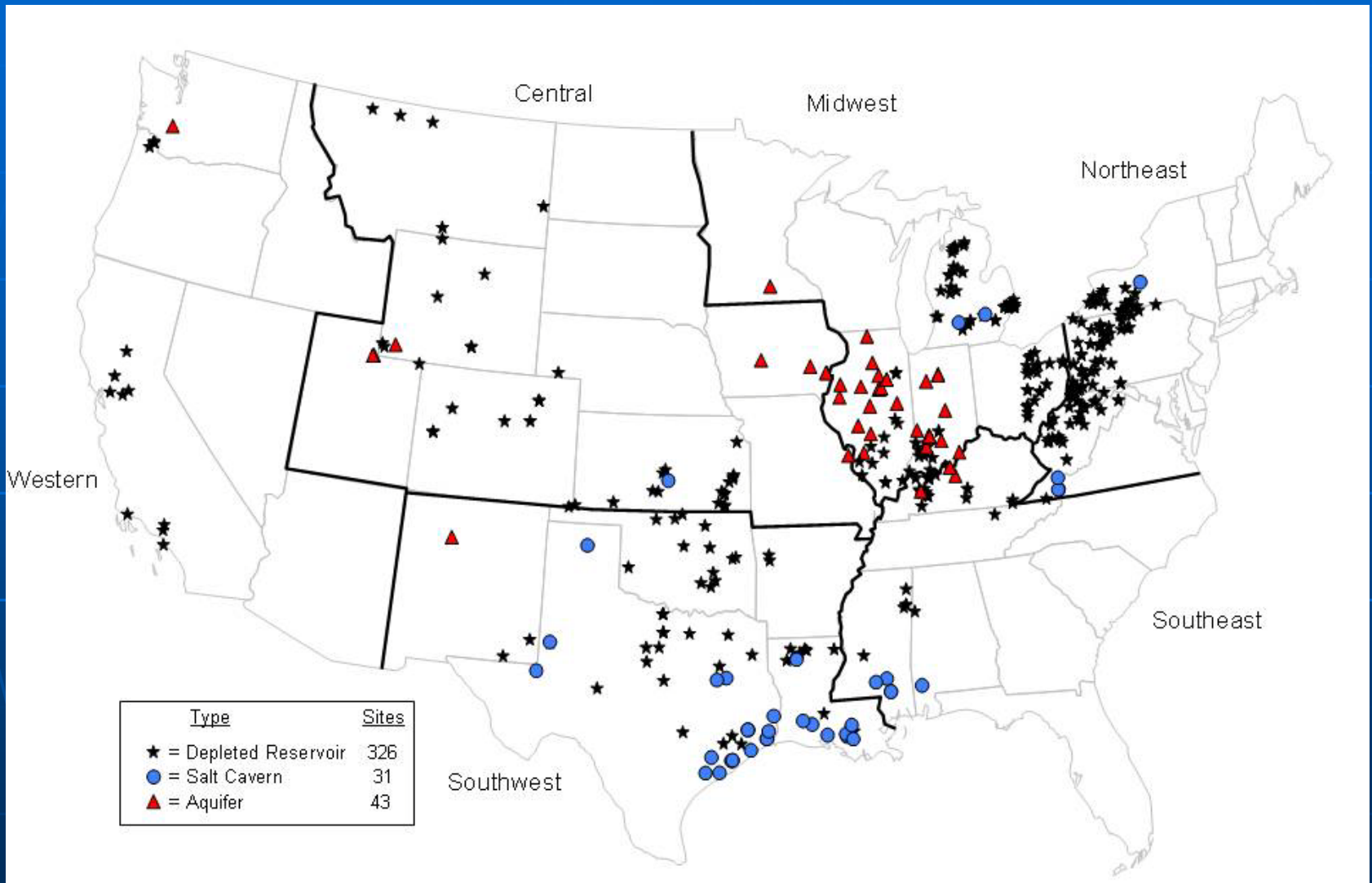




Hydrocarbon storage cavern



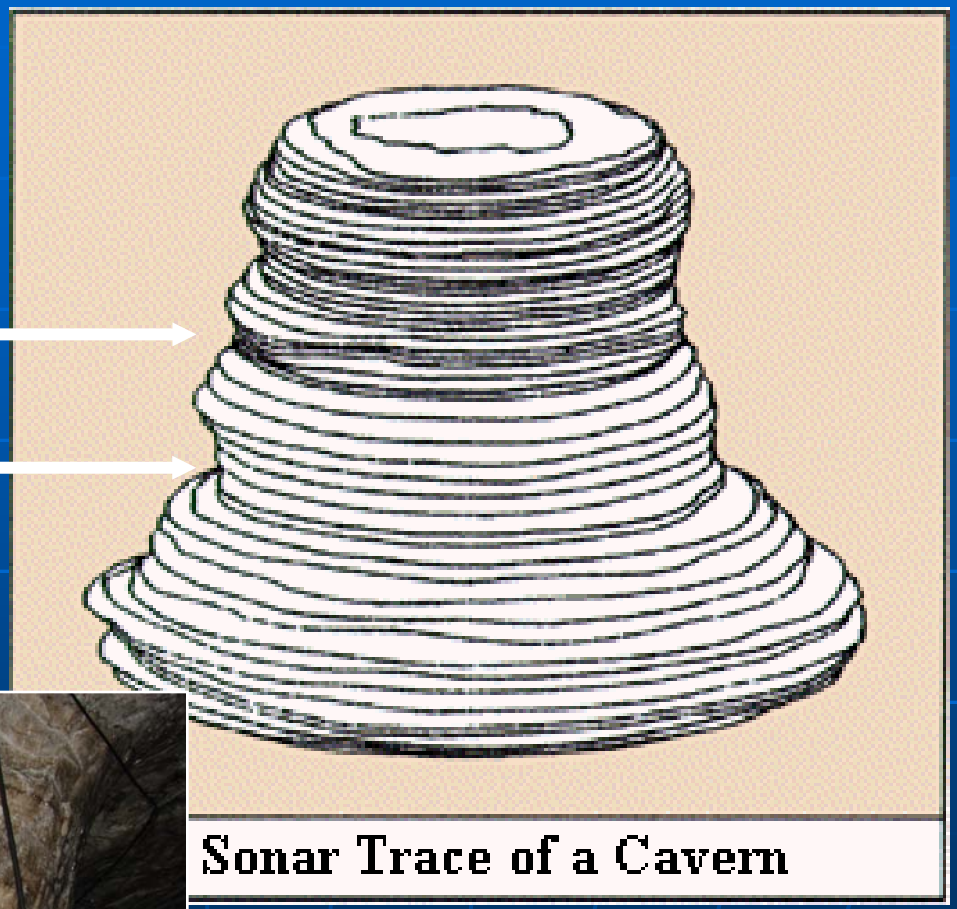
Natural Gas Storage in Caverns – U.S.



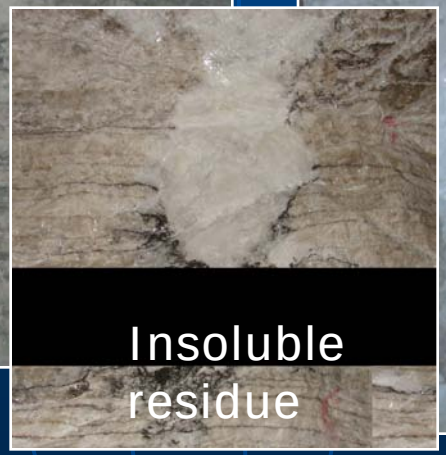
Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division Gas, Gas Transportation Information System, December 2008.

Ledges in caverns

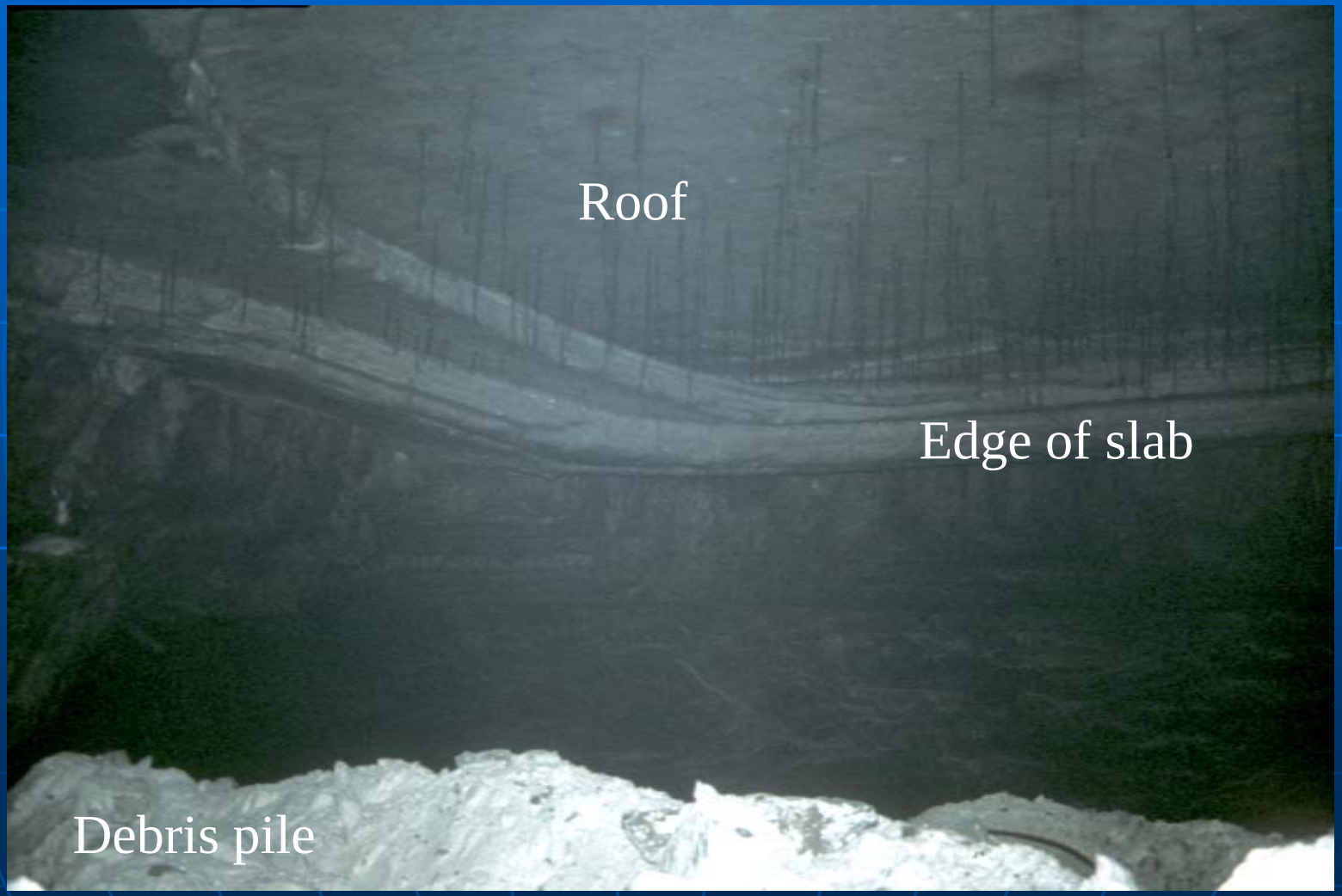
Interbeds of insoluble limestone, anhydrite form ledges in caverns



Salt dissolution and recrystallization



Roof slabbing and debris pile

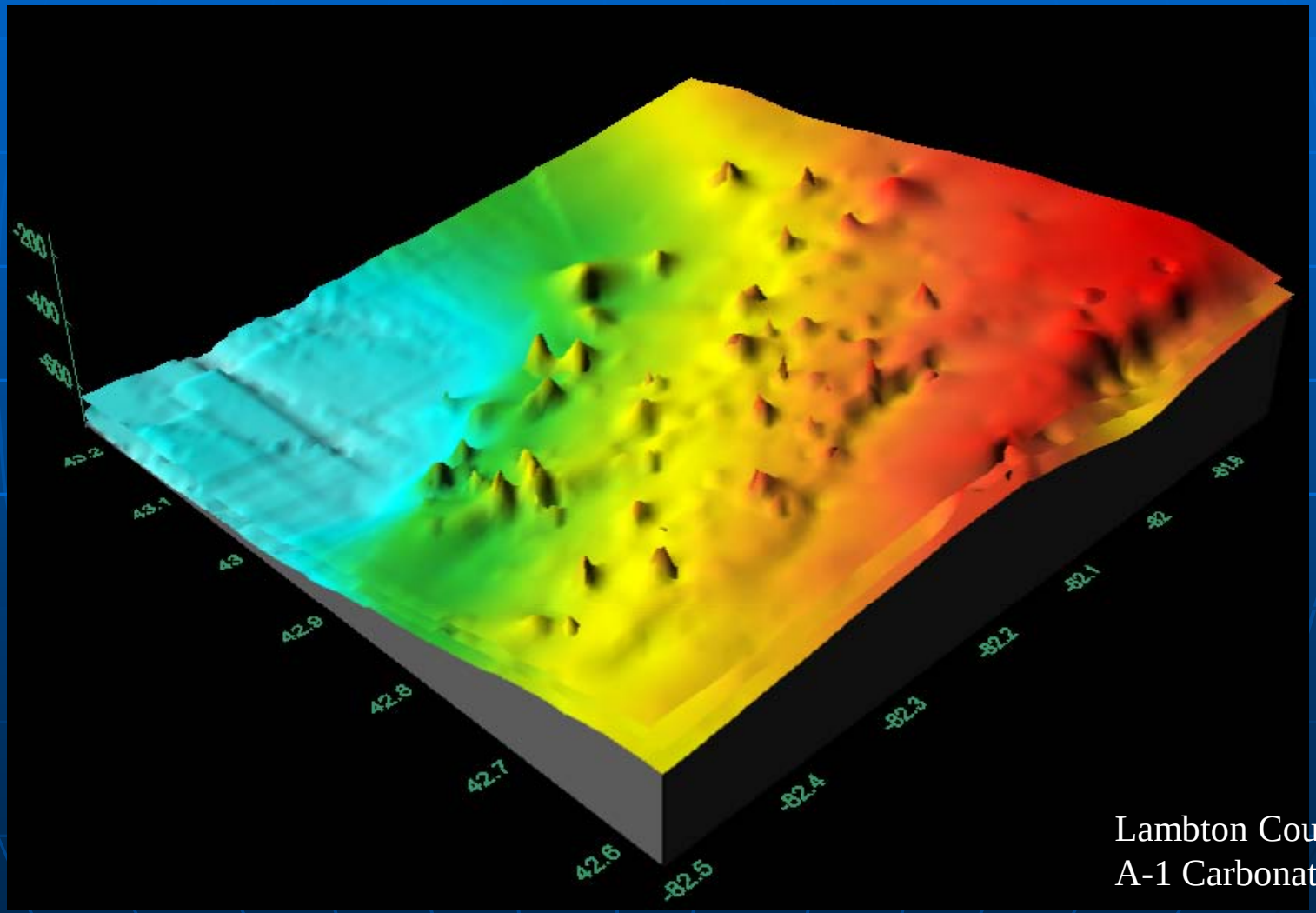


Summary

- Bedded salt occurs in several layers tens of metres, 275-775 m depth, underlying up to 16,000 km^2 in subsurface of Ontario
- Salt layers deposited on floor of ancient sea
- Post-depositional dissolution of salt in subsurface – recrystallised salt, dissolution fronts, breccias
- Underground mining and solution mining at two locations
- 70 solution-mined caverns used for storage of hydrocarbons
- Non-salt layers in the salt beds may interfere with solution mining and cavern storage operations
- Natural gas storage and oil/gas production in reef structures beneath the salt

3D Subsurface Geology

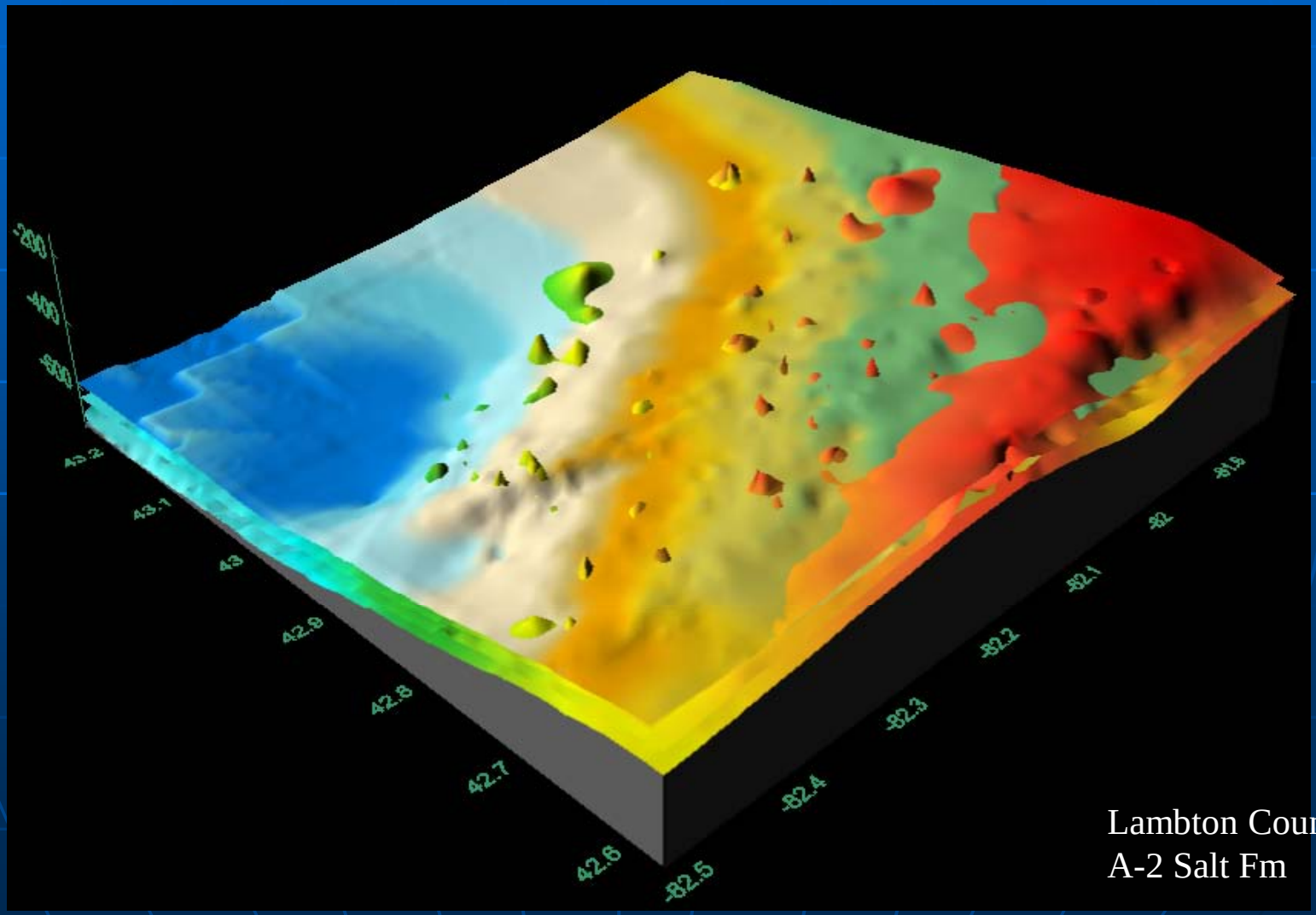
Partial burial of reefs by lime mud



Lambton County –
A-1 Carbonate Fm

3D Subsurface Geology

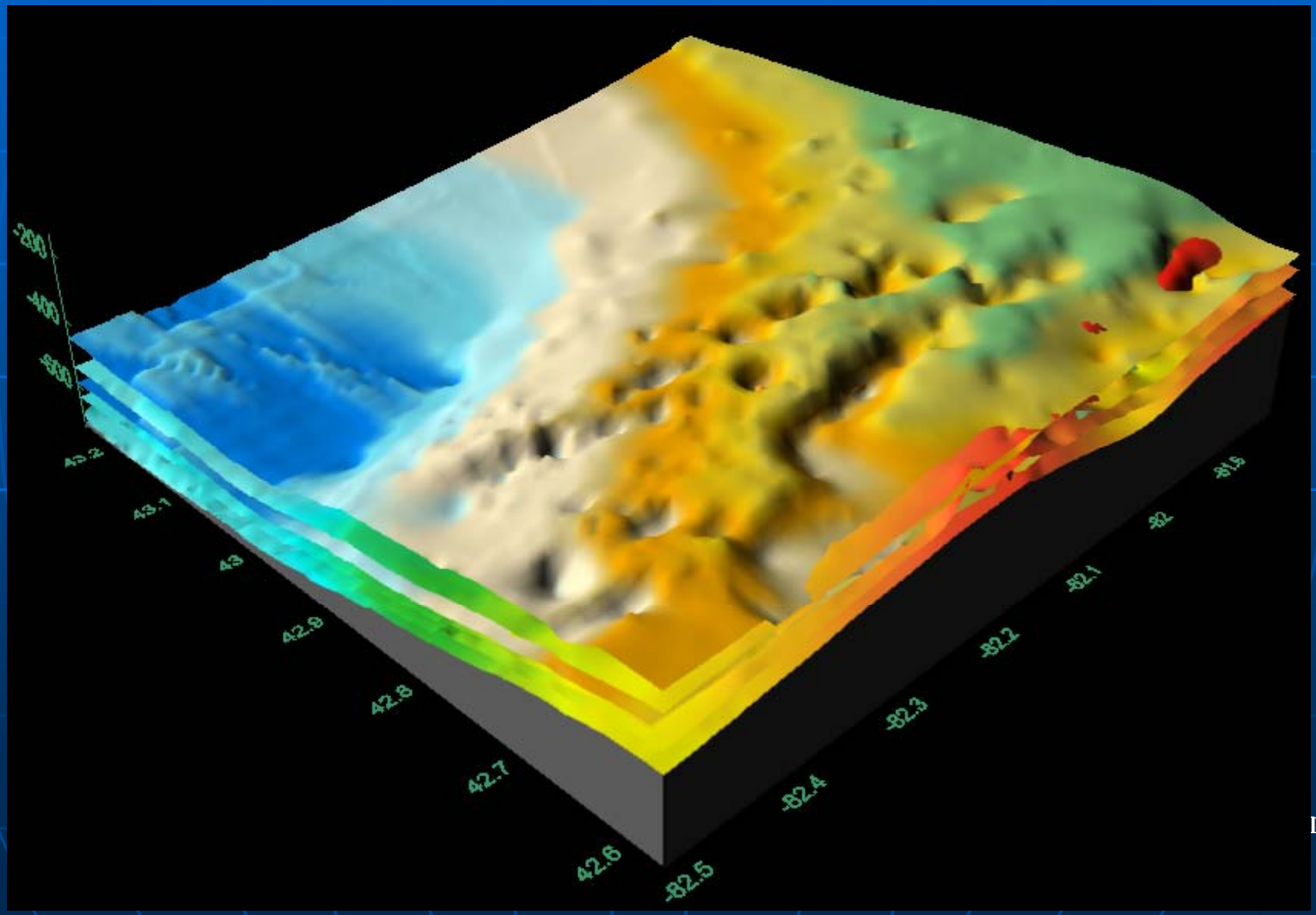
First salt deposition – A-2 Salt



Lambton County –
A-2 Salt Fm

3D Subsurface Geology

Deposition of B Salt



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