“Forest rings” and their implications for geochemical exploration of oil, gas and mineral deposits

AAG Distinguished Lecturer Series

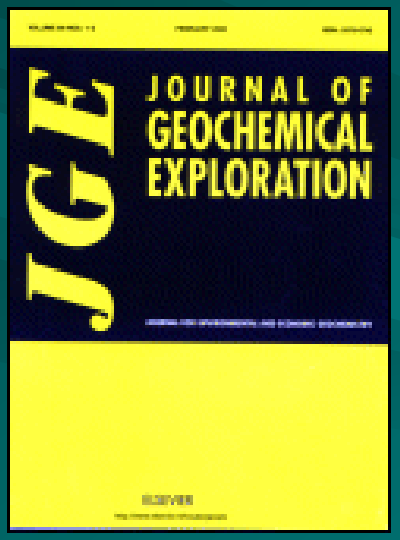
Stewart M. Hamilton

Ontario Geological Survey

THE ASSOCIATION OF APPLIED GEOCHEMISTS

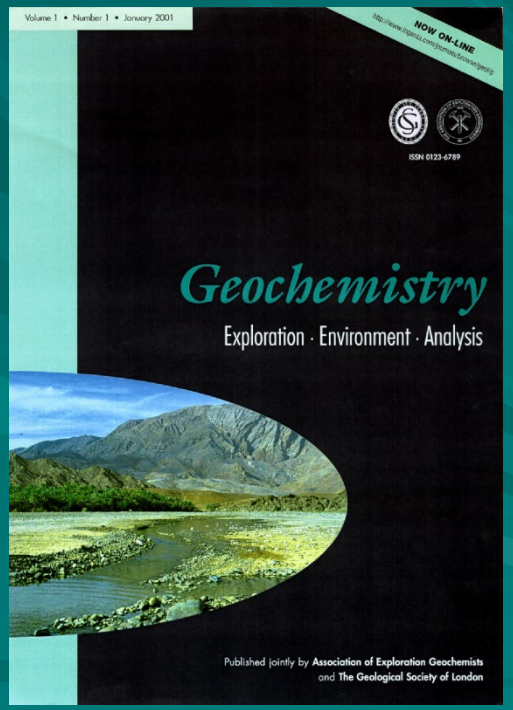
The Association's Journal

Elsevier



1972-1999

Geological Society of London



2001-present

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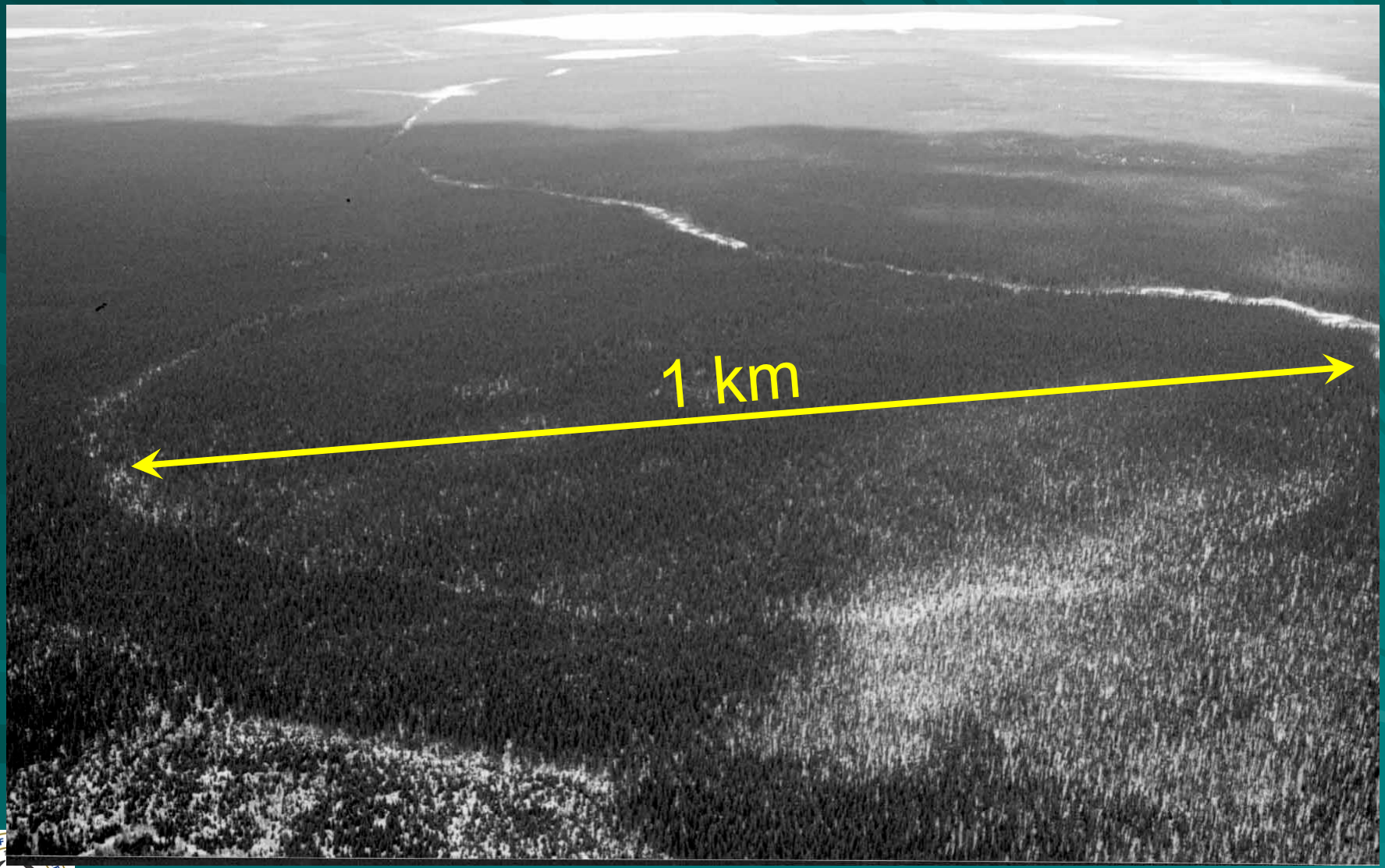
Forest Rings

OGS Photo

Ontario Geological Survey

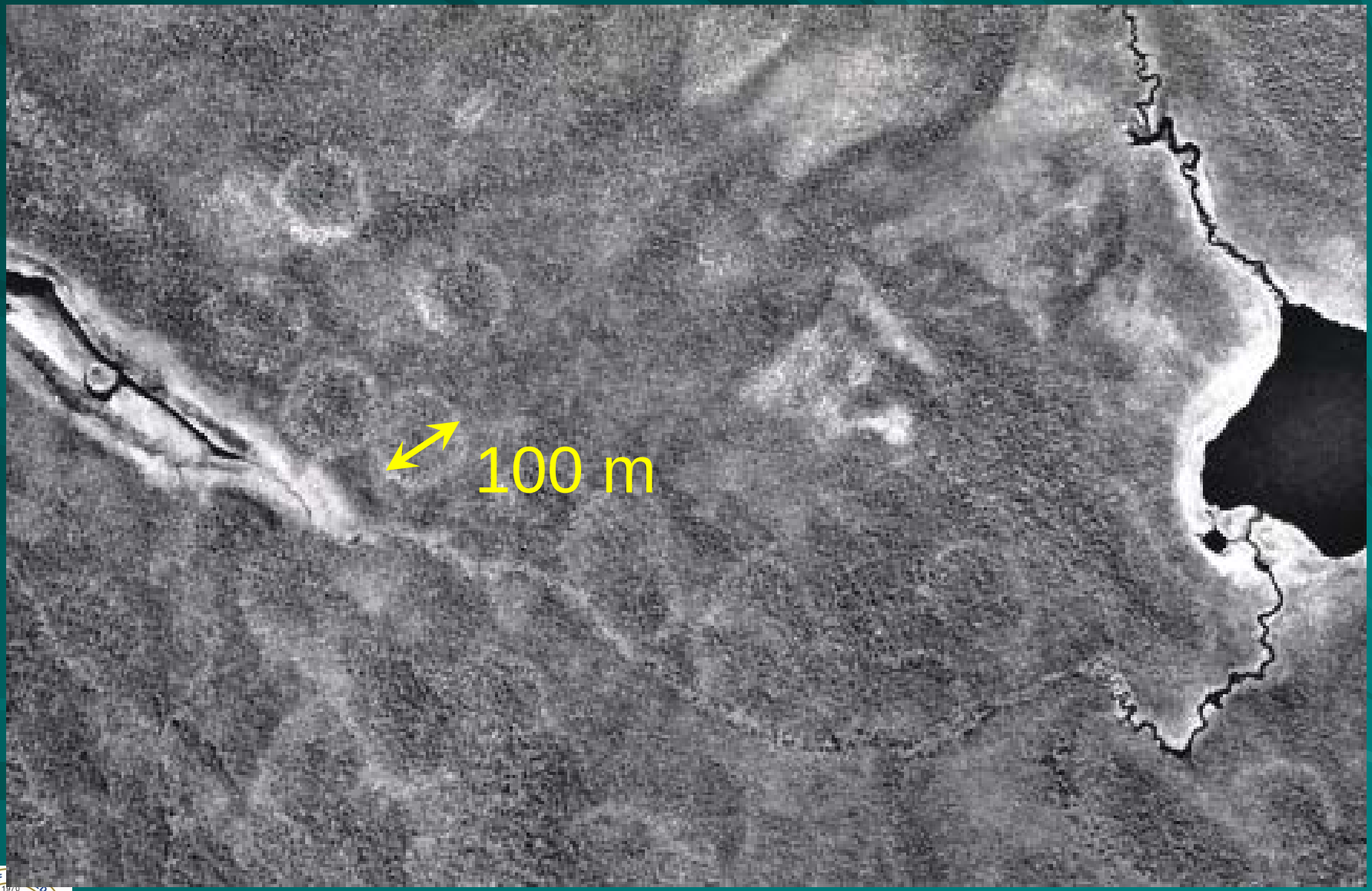
Cheecka Ring, near Hearst



OGS Photo

Ontario Geological Survey

Small rings, northeastern Ontario



MNR Air Photo

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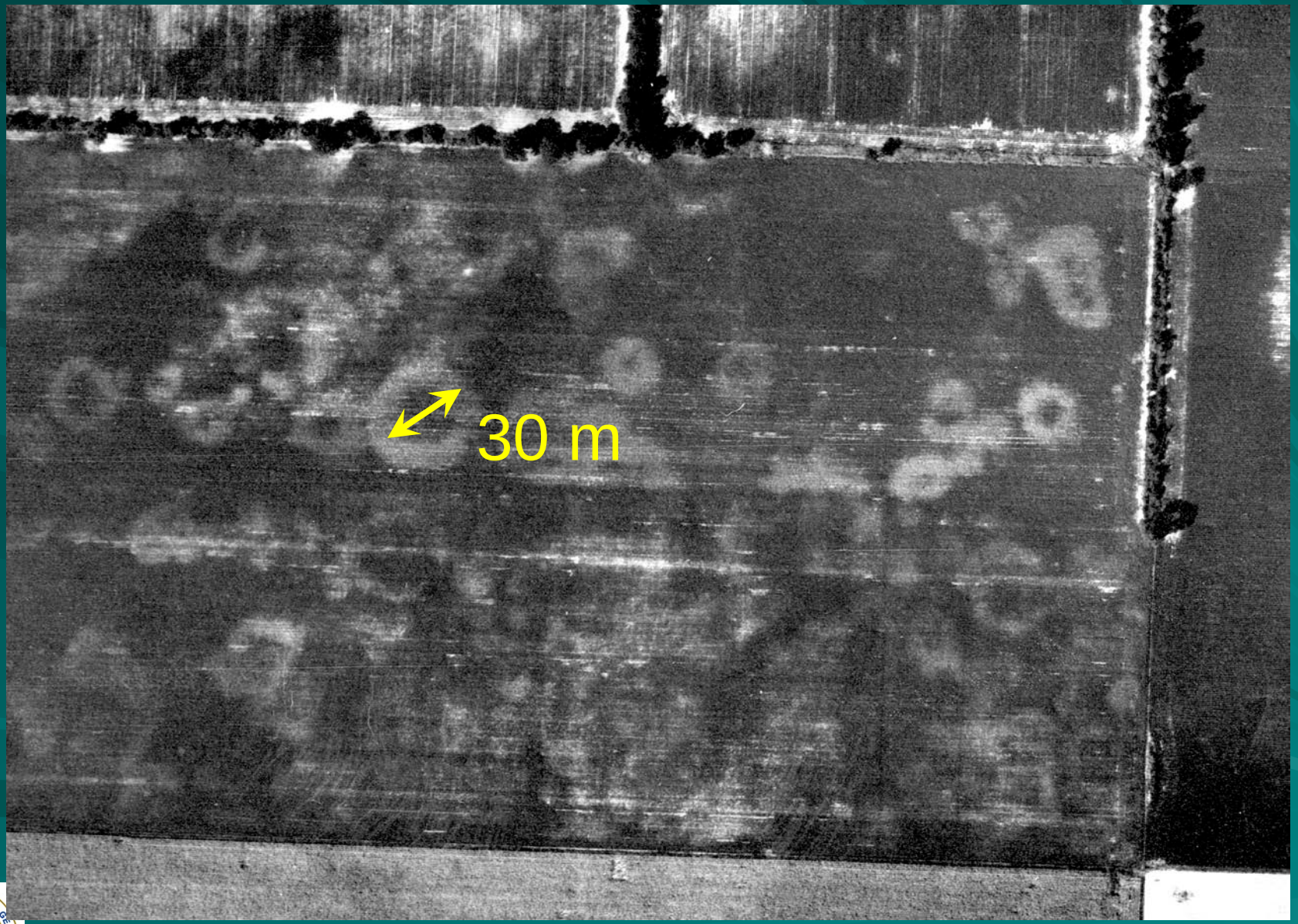
Crop rings in farm fields (the real ones)



Source: Tom Morris, OGS

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Ring in limestone, base of quarry

Photo: Tom Morris (OGS)

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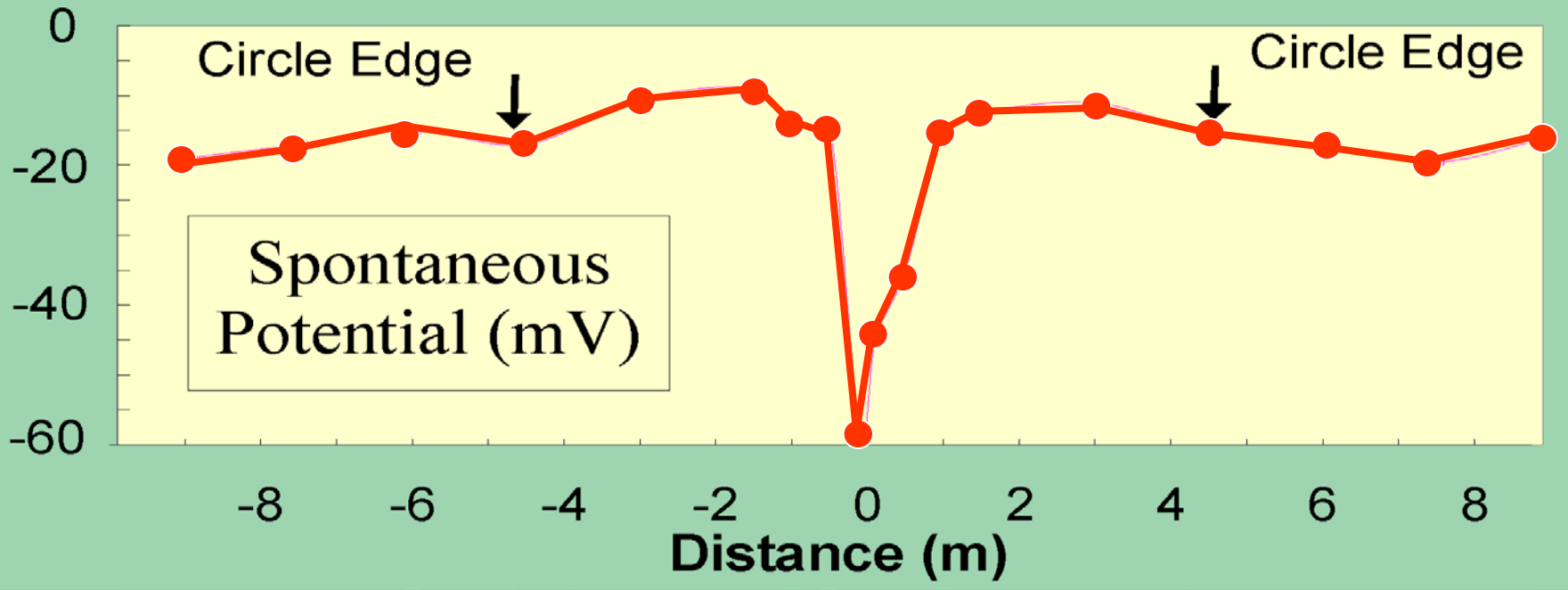
Ring formation around a well casing



Detailed Study Areas

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Forest Rings - “Bean” Ring

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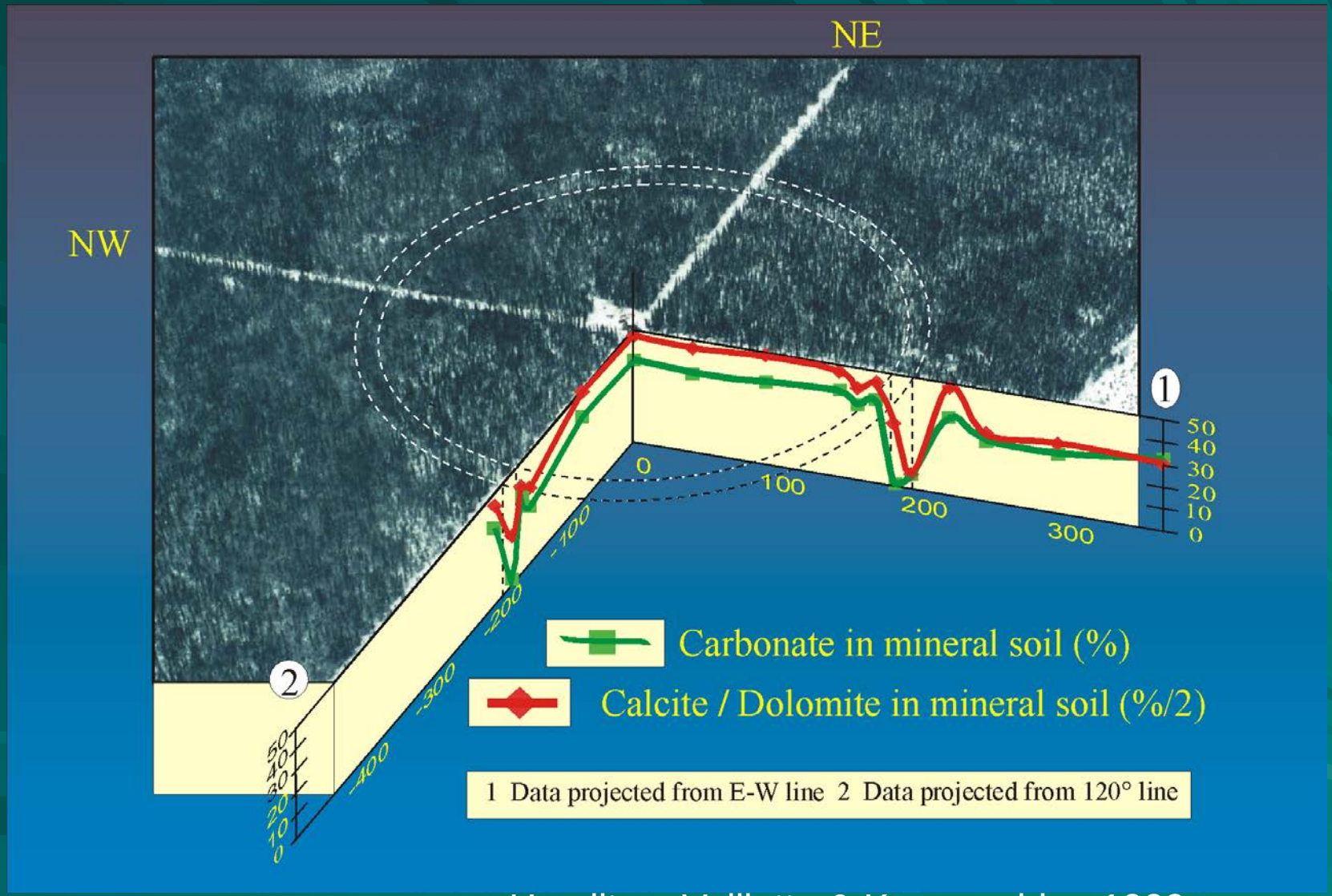
Forest Rings - “Bean” Ring



Hamilton, Veillette & Komarechka, 1999

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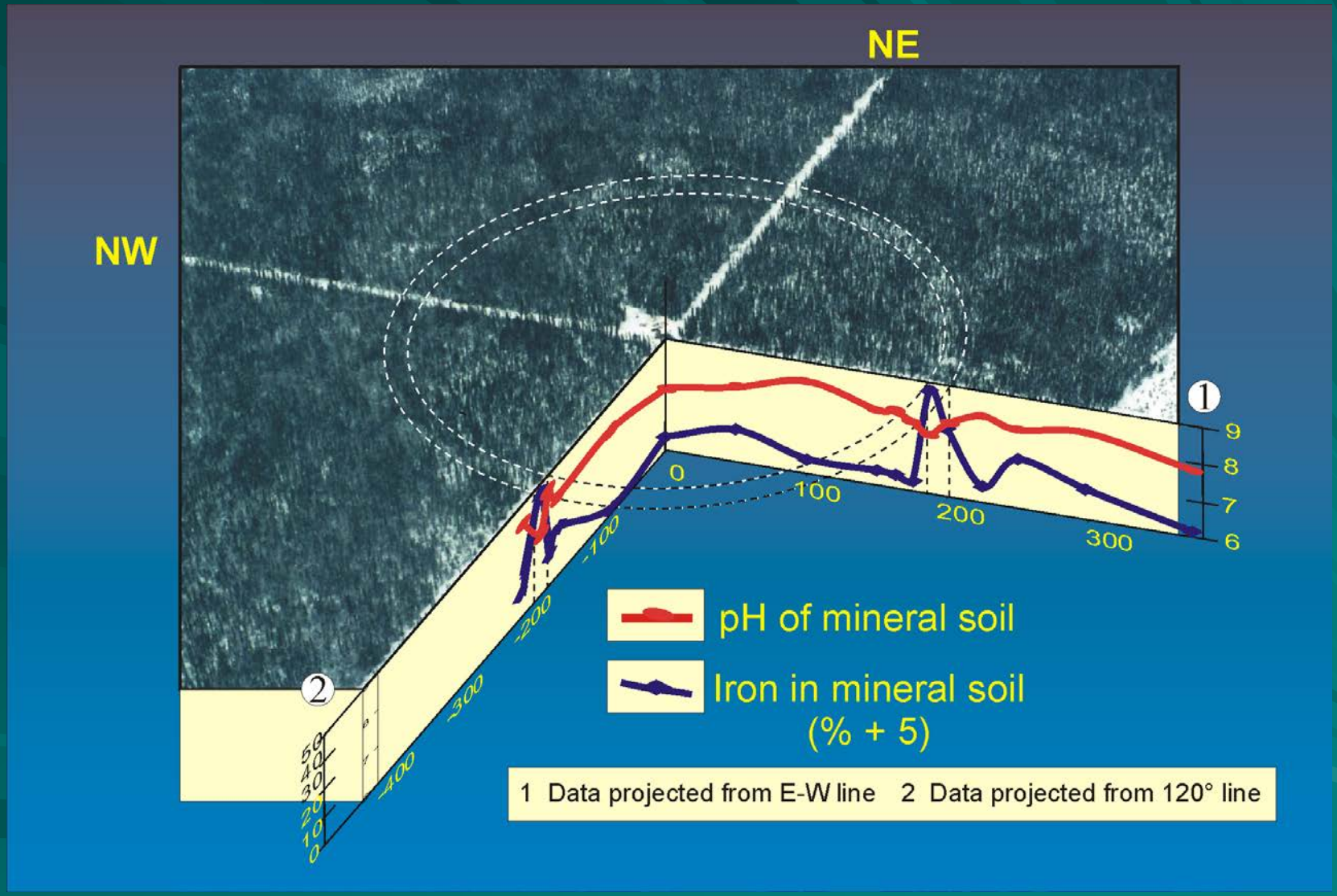
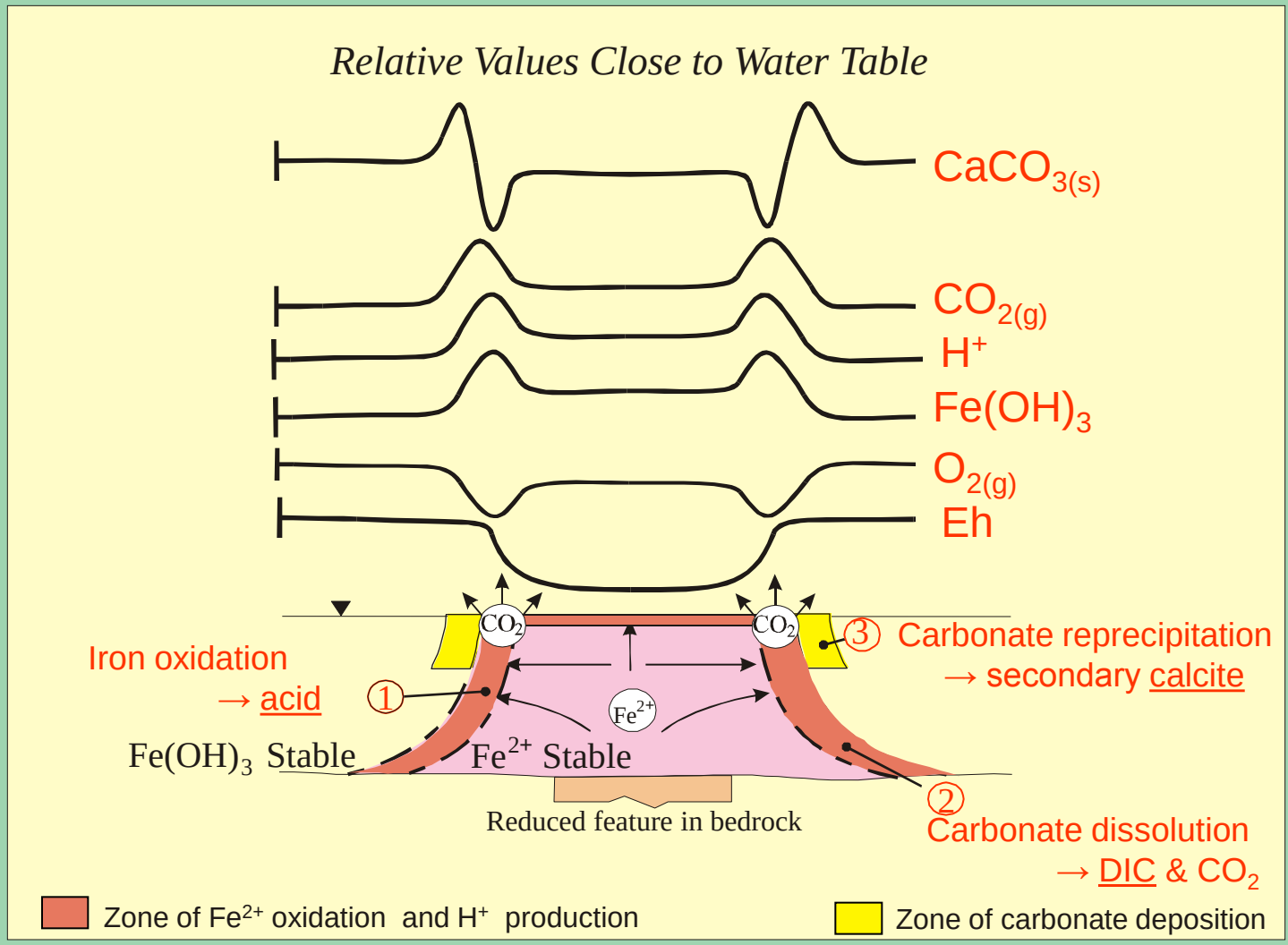
Forest Rings - “Bean” Ring



Hamilton, Veillette & Komarechka, 1999

Model for Ring Formation



Hamilton, 1999; 2000

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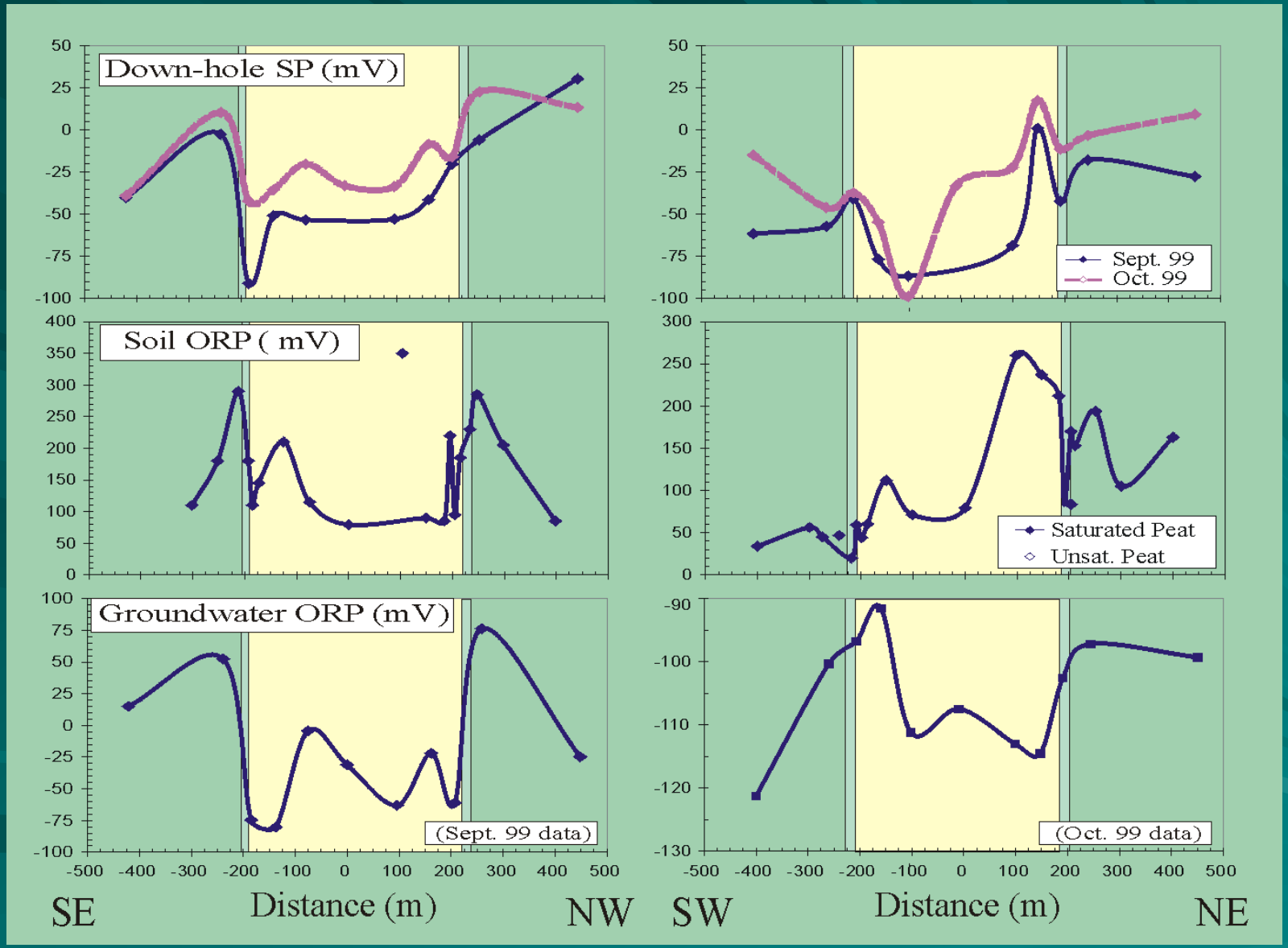
Redox - Bean Ring



Hamilton and Cranston, 2001

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Natural Gas, Bean Ring

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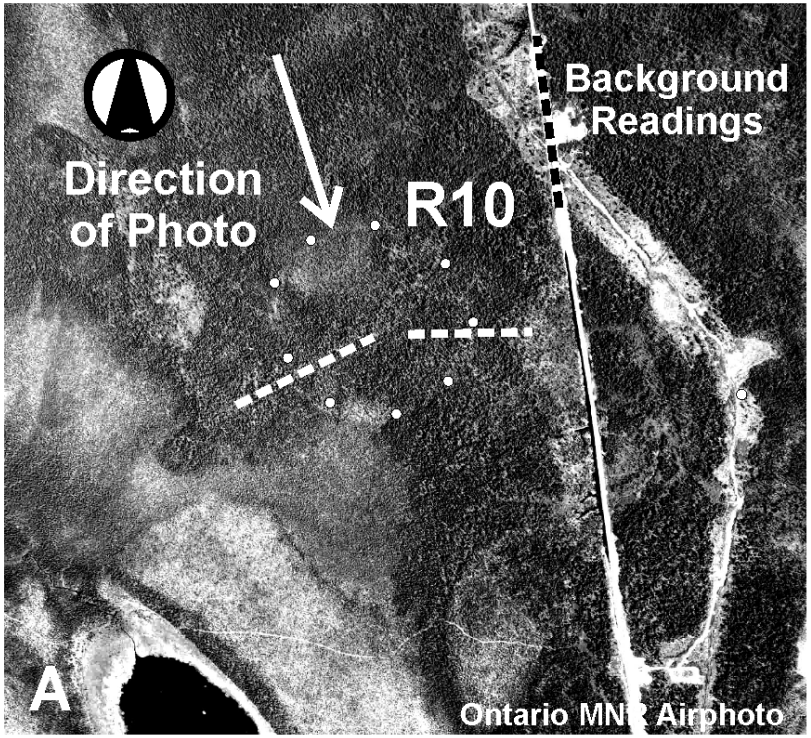
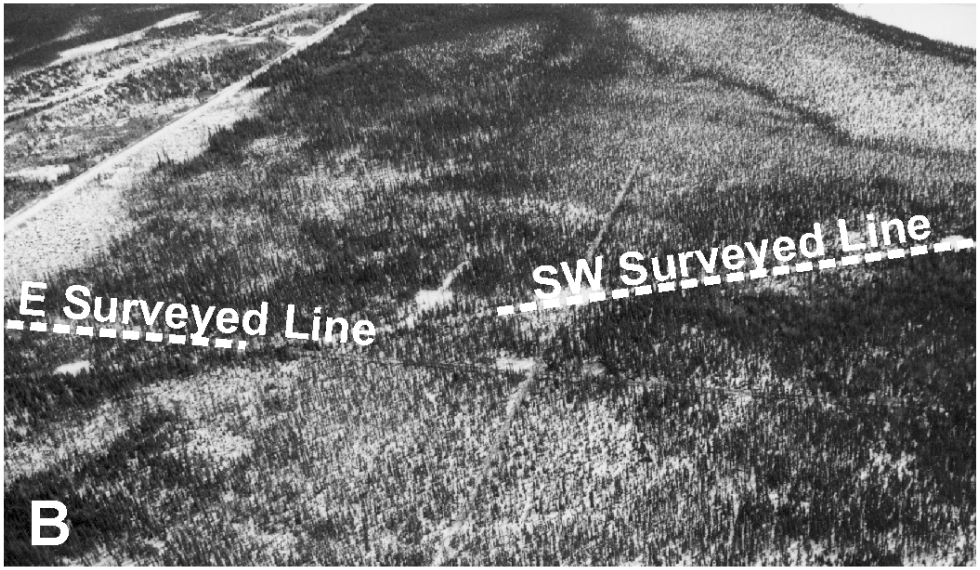
Thorn-North Ring





Hamilton et al., 2004

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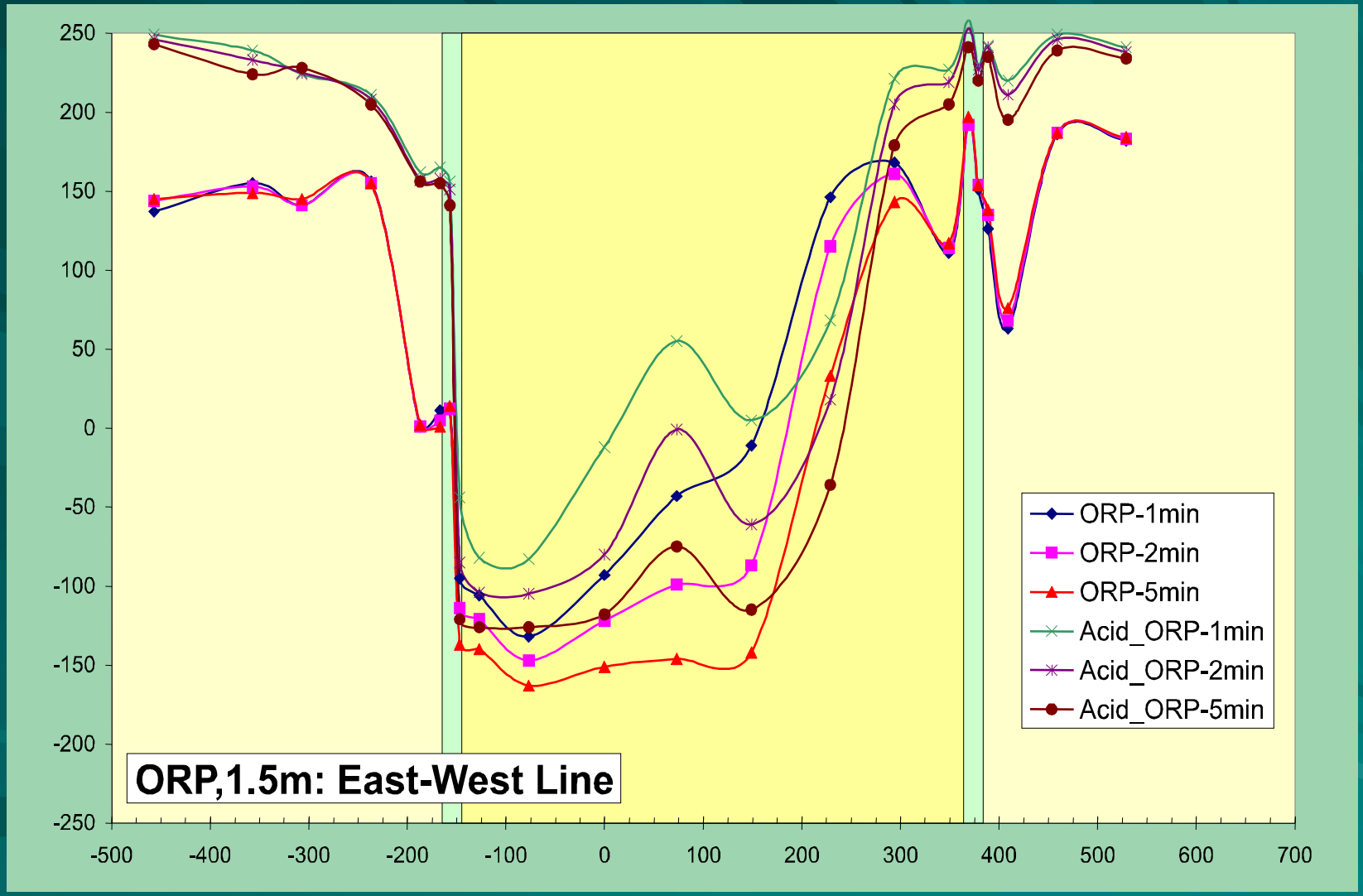
Redox in Soils @ 1.5m depth - Thorn-N Ring



Hamilton and Cranston, 2000

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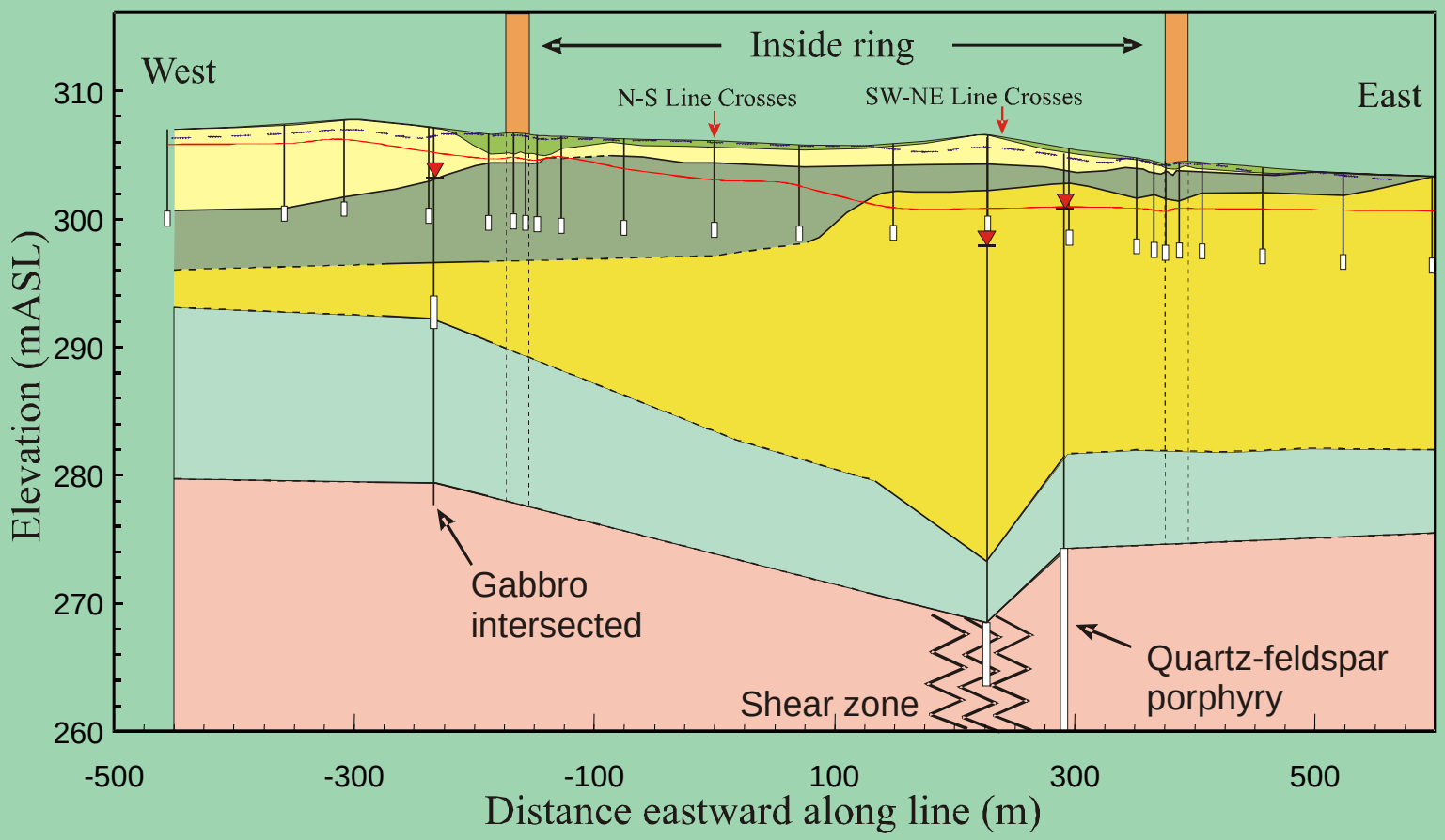
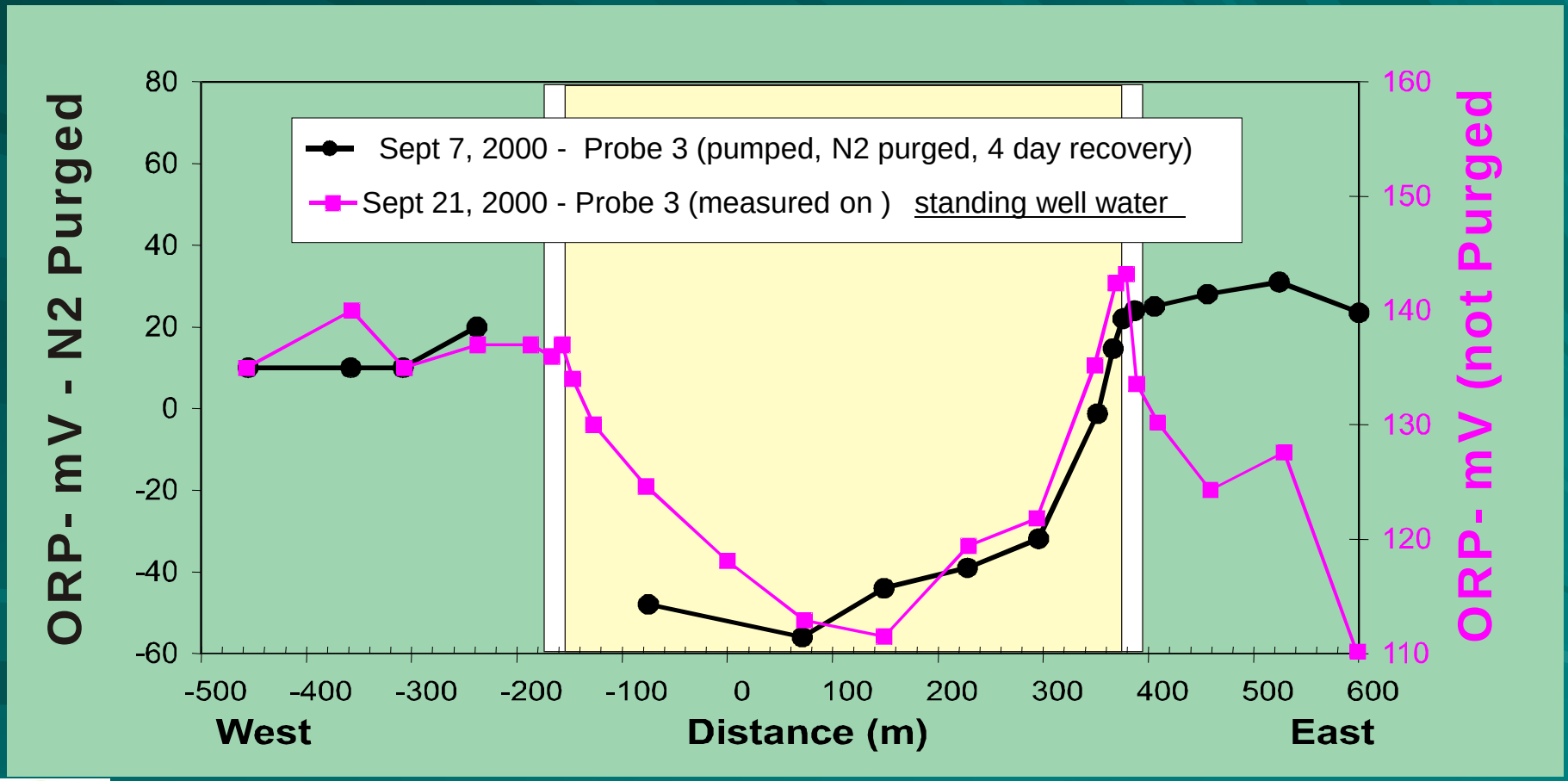
Overburden Stratigraphy, Thorn-North Ring



ORP of Groundwater, 8 m Depth Thorn-North Ring



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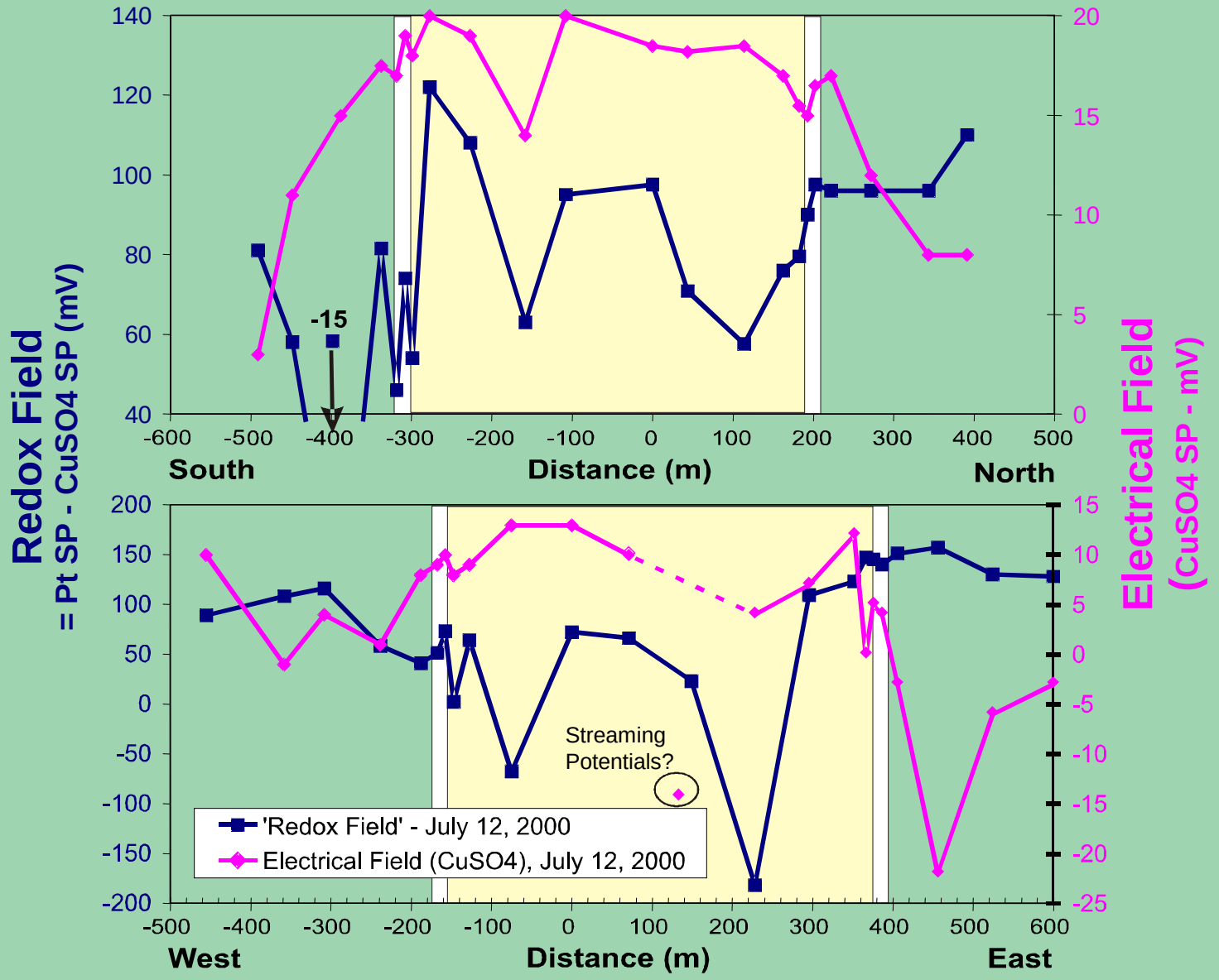
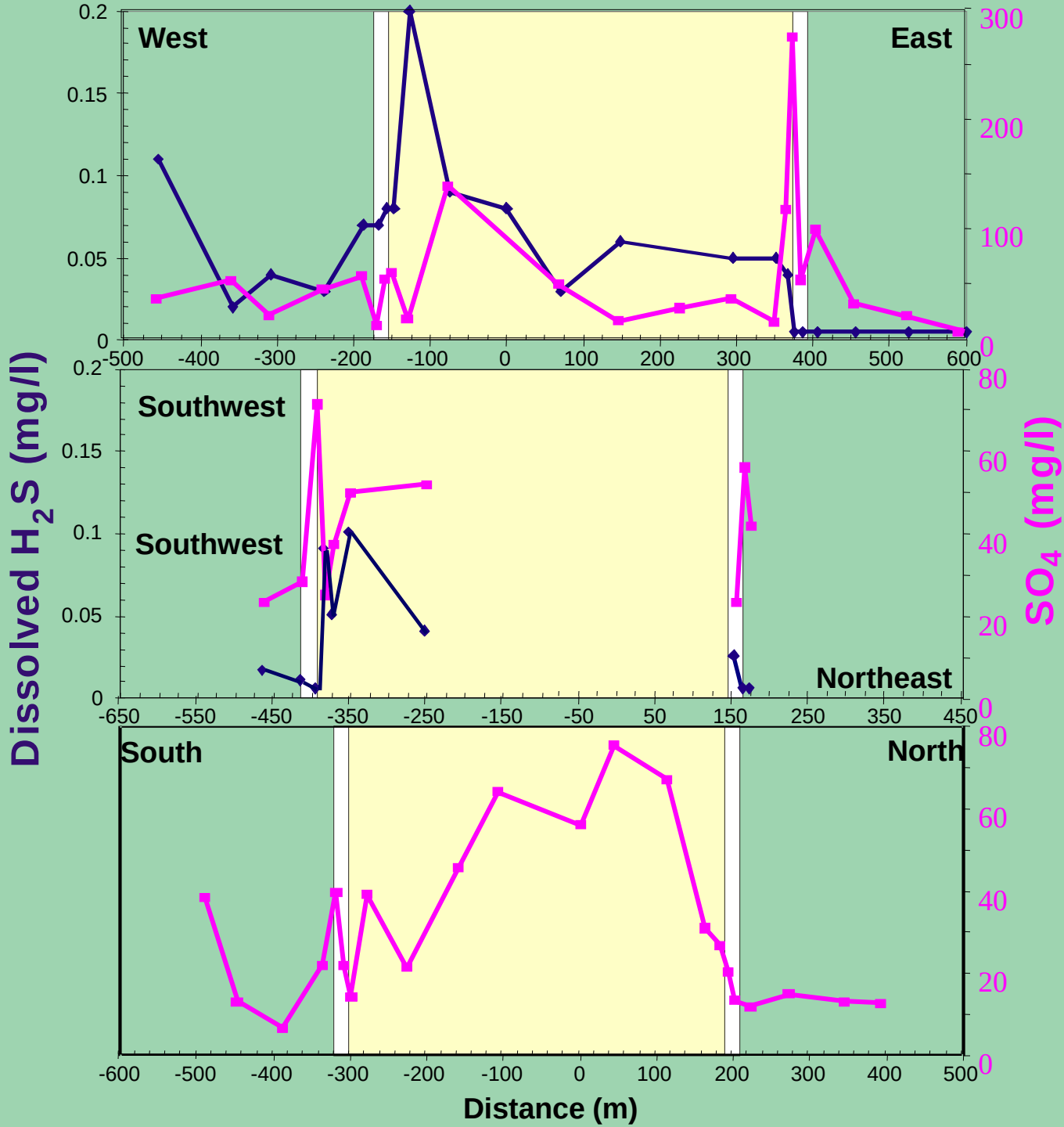
Down-Hole SP Redox Field

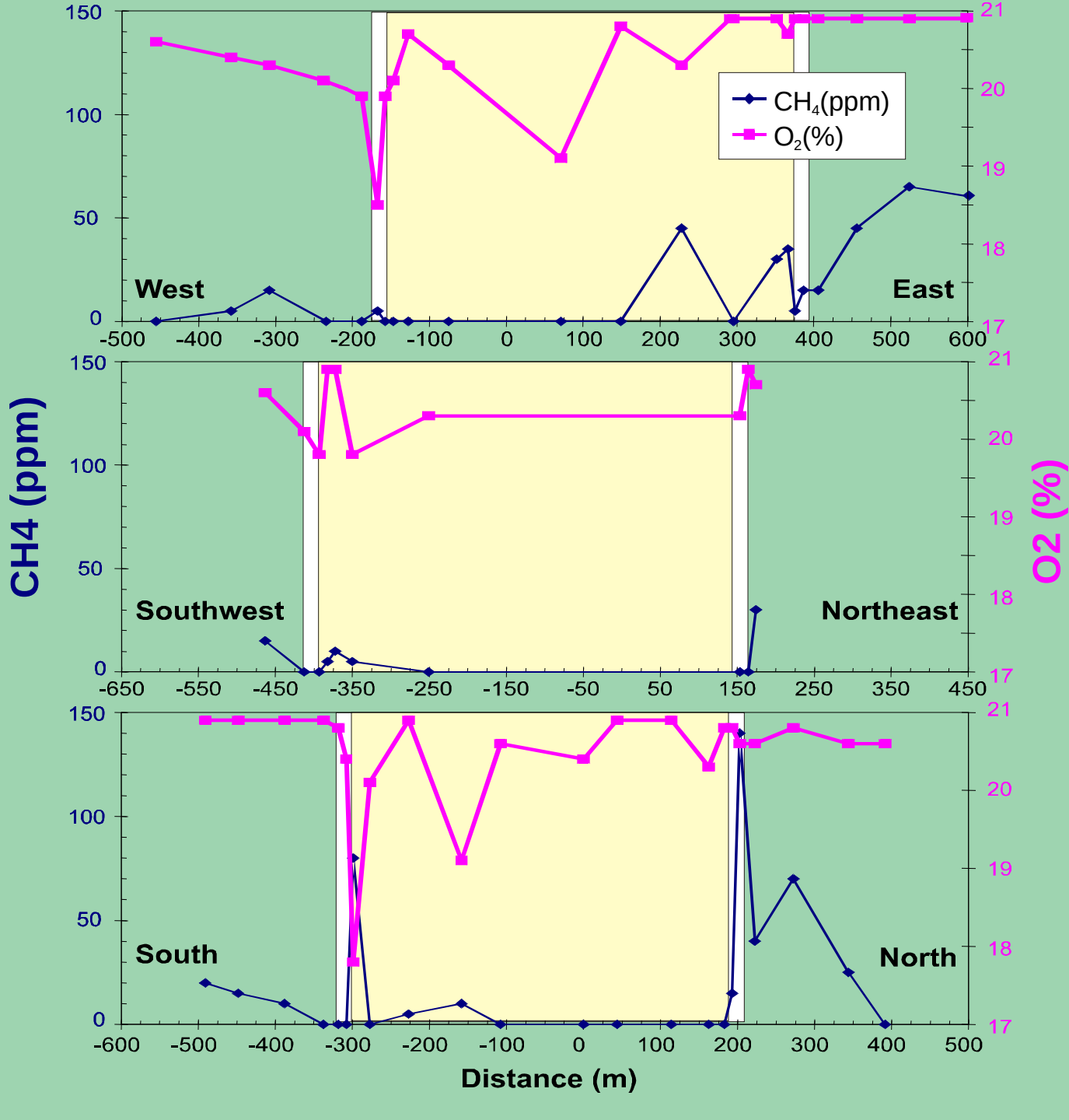
Electrical Field



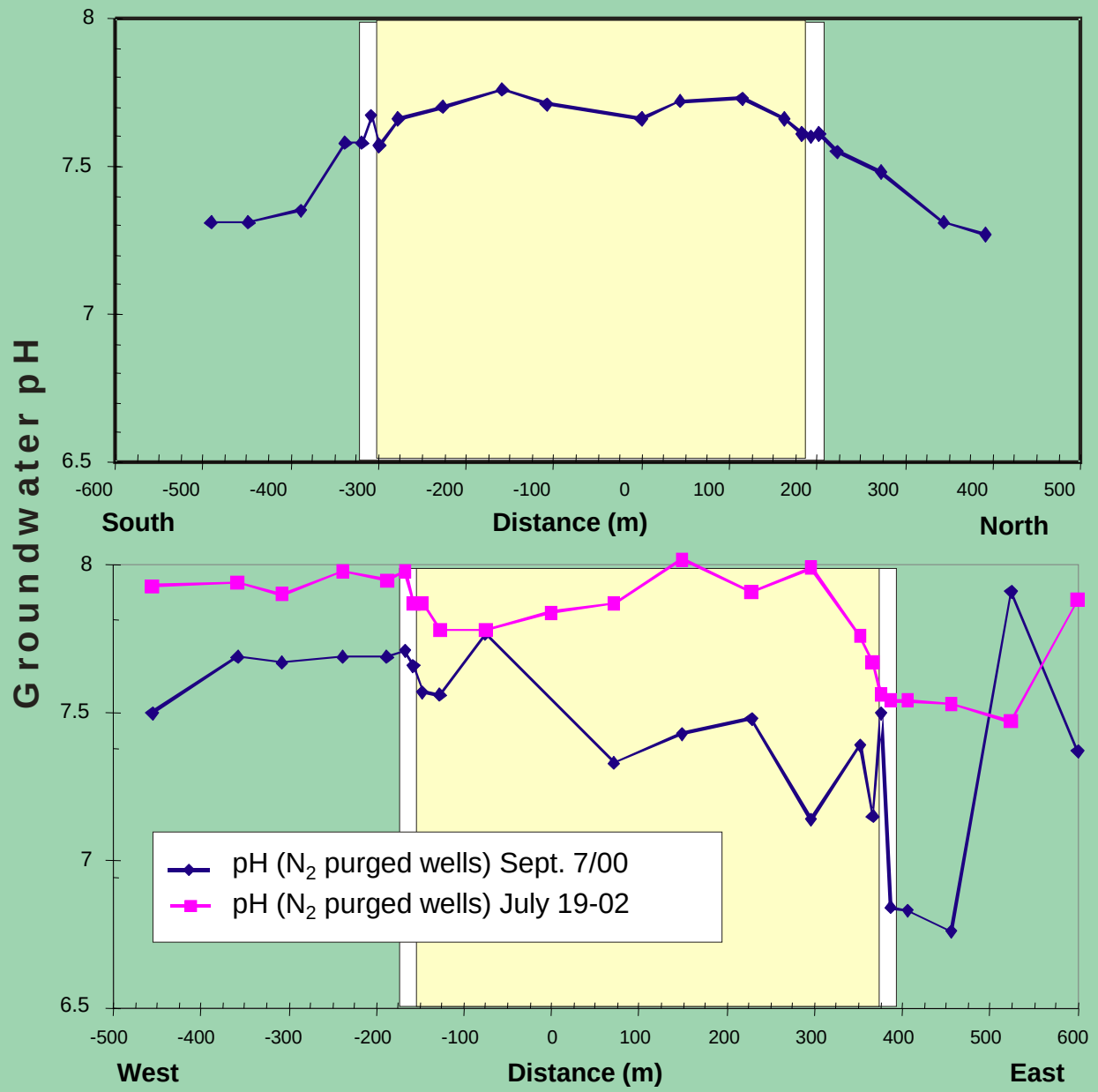
H_2S & SO_4^{2-} in Groundwater



Methane and Oxygen in Well Headspace



pH of Groundwater



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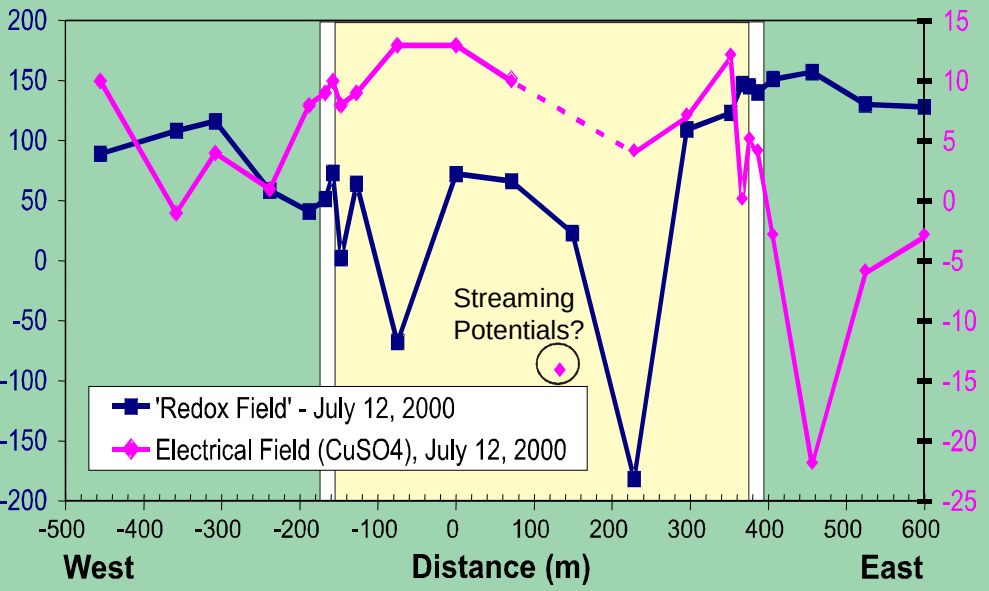
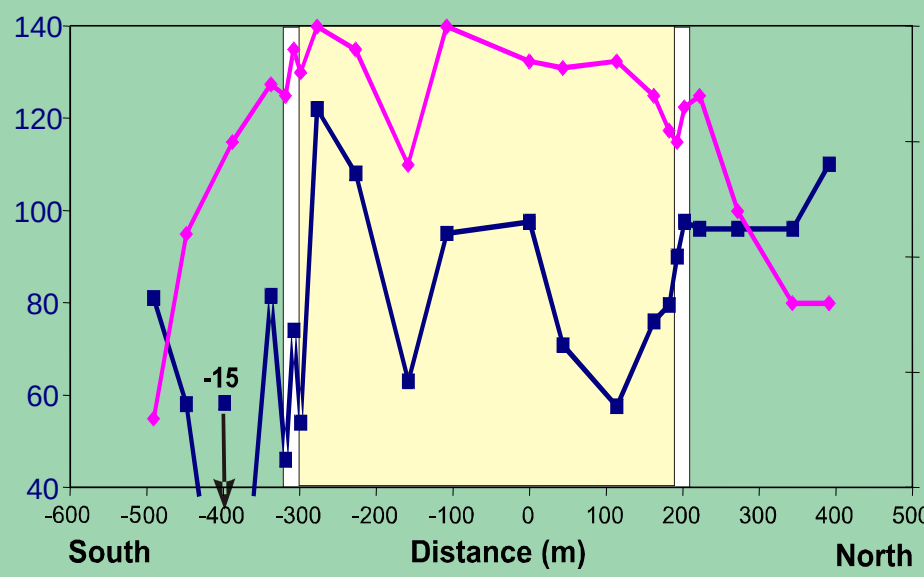
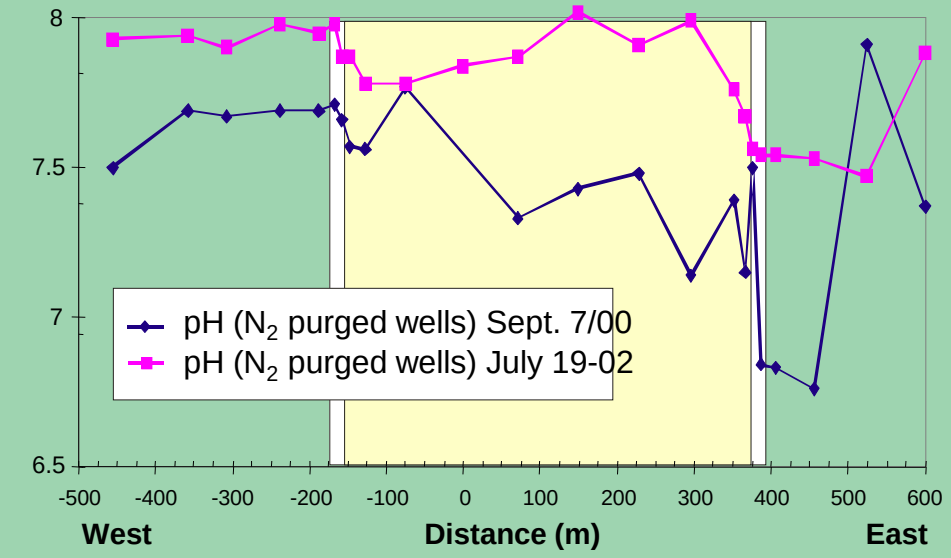
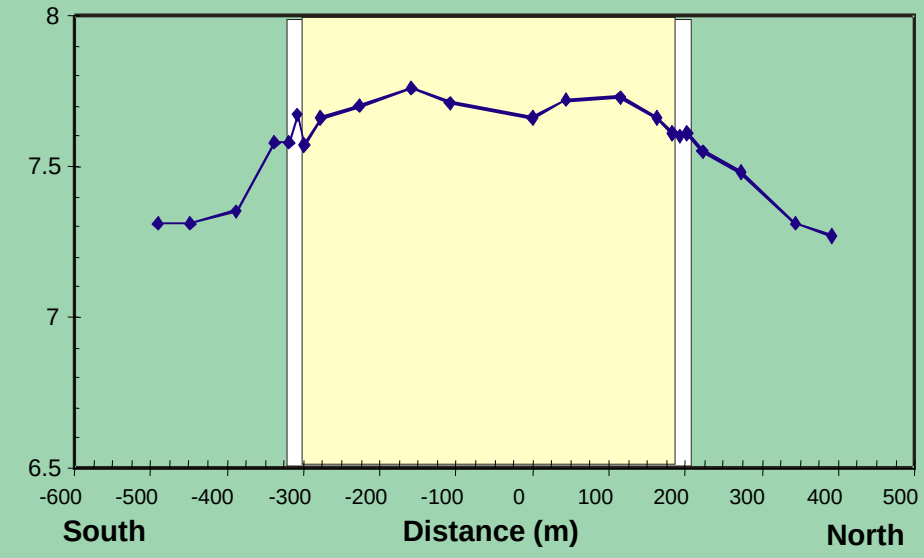
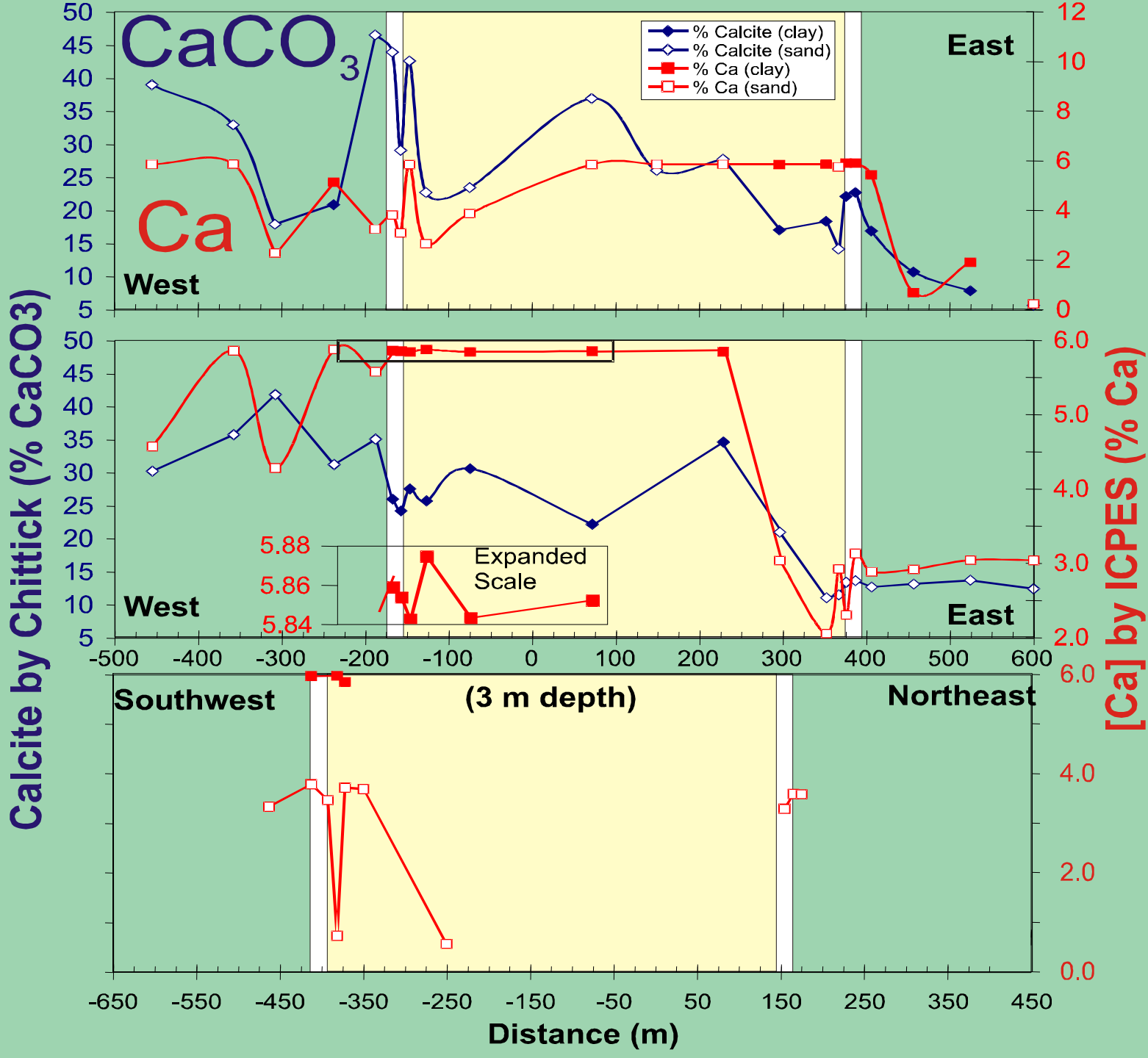

Streaming Potentials?
'Redox Field' - July 12, 2000
Electrical Field (CuSO4), July 12, 2000
West
Distance (m)
East


-15
South
Distance (m)
North

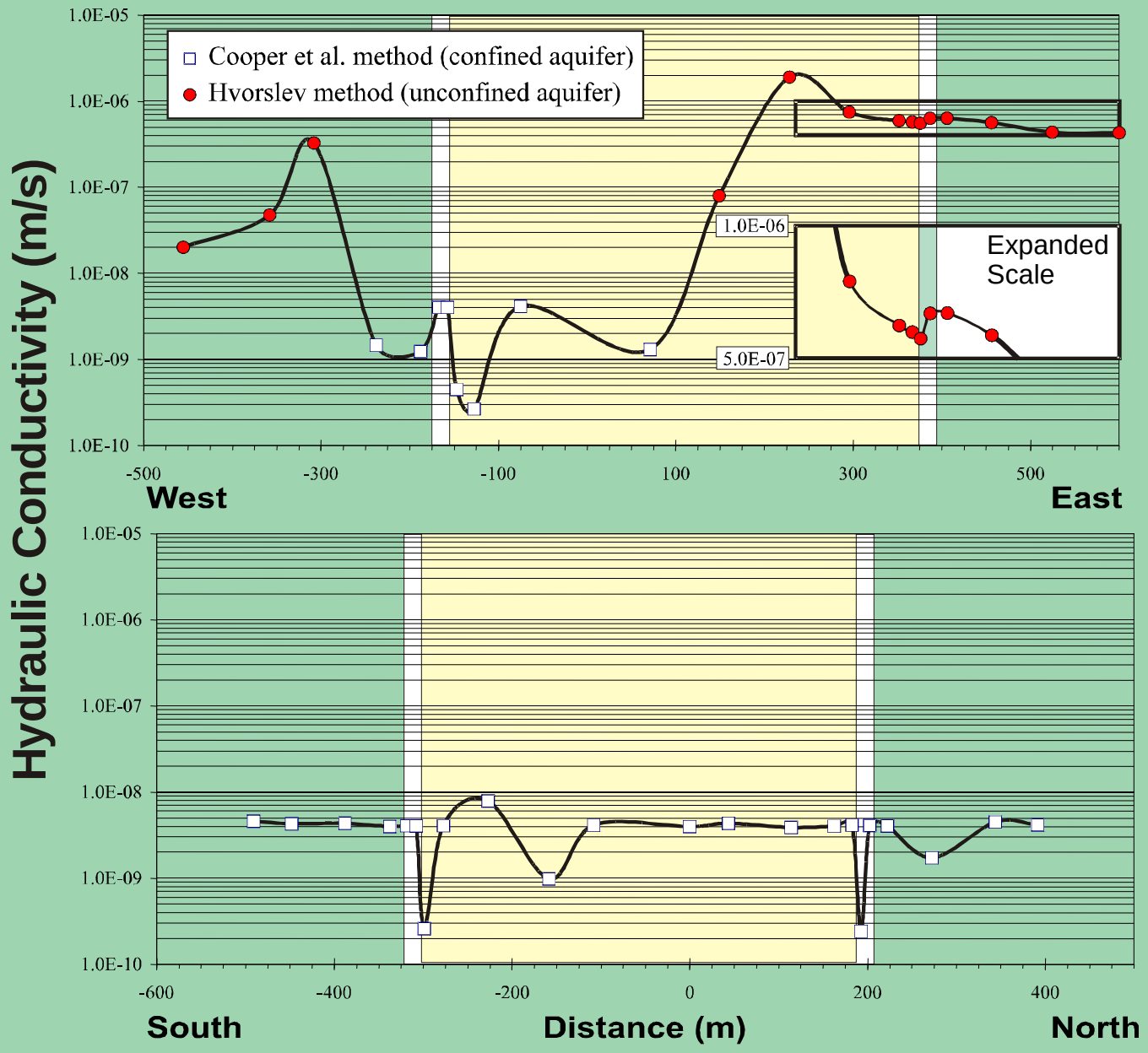

pH (N_2 purged wells) Sept. 7/00
pH (N_2 purged wells) July 19-02
West
Distance (m)
East


South
Distance (m)
North

Carbonate in Sediment



Permeability of Sediments



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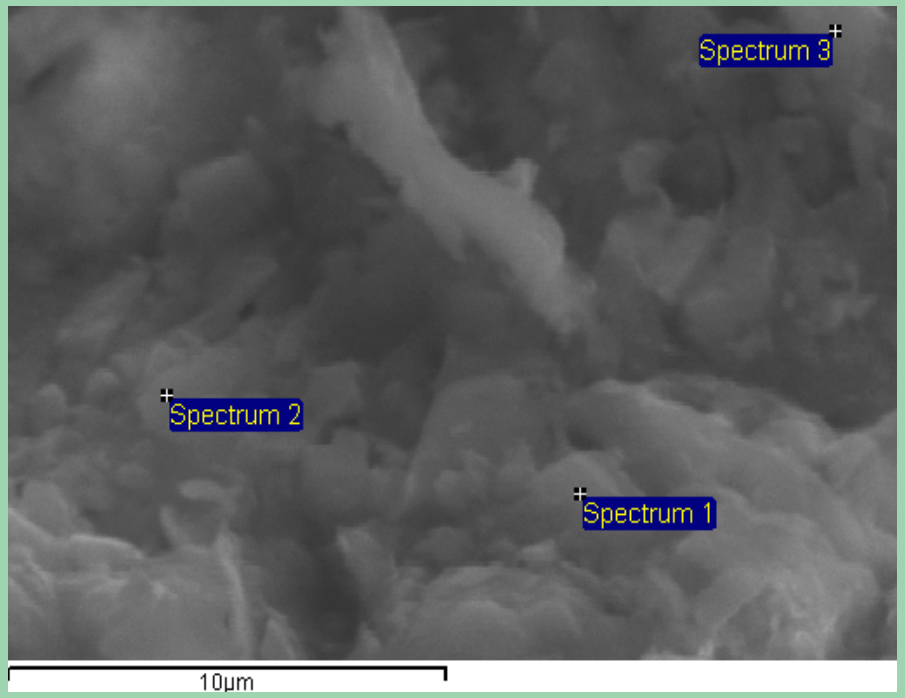
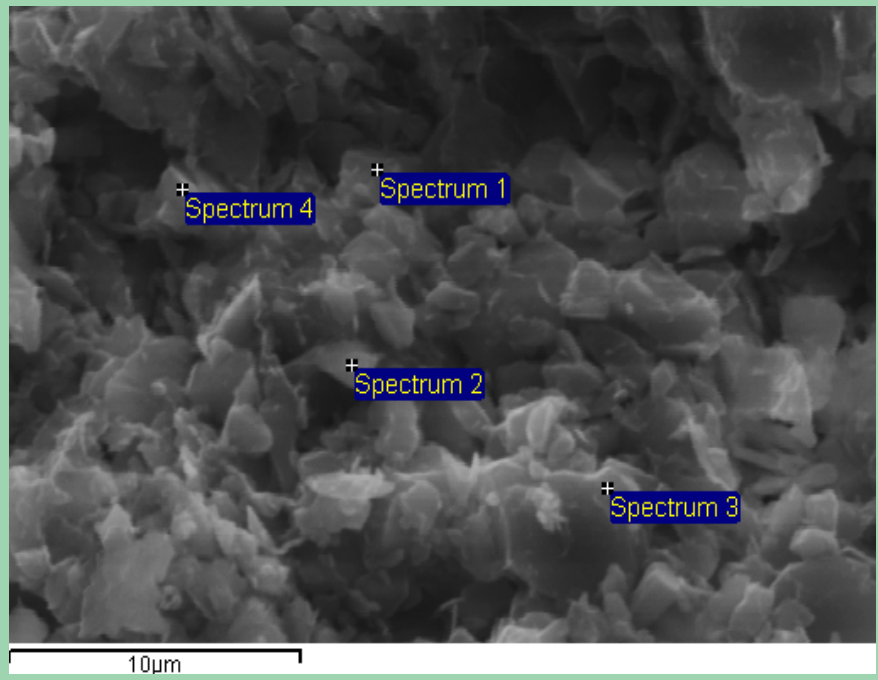
Carbonate Mobility (Cheecka Ring)



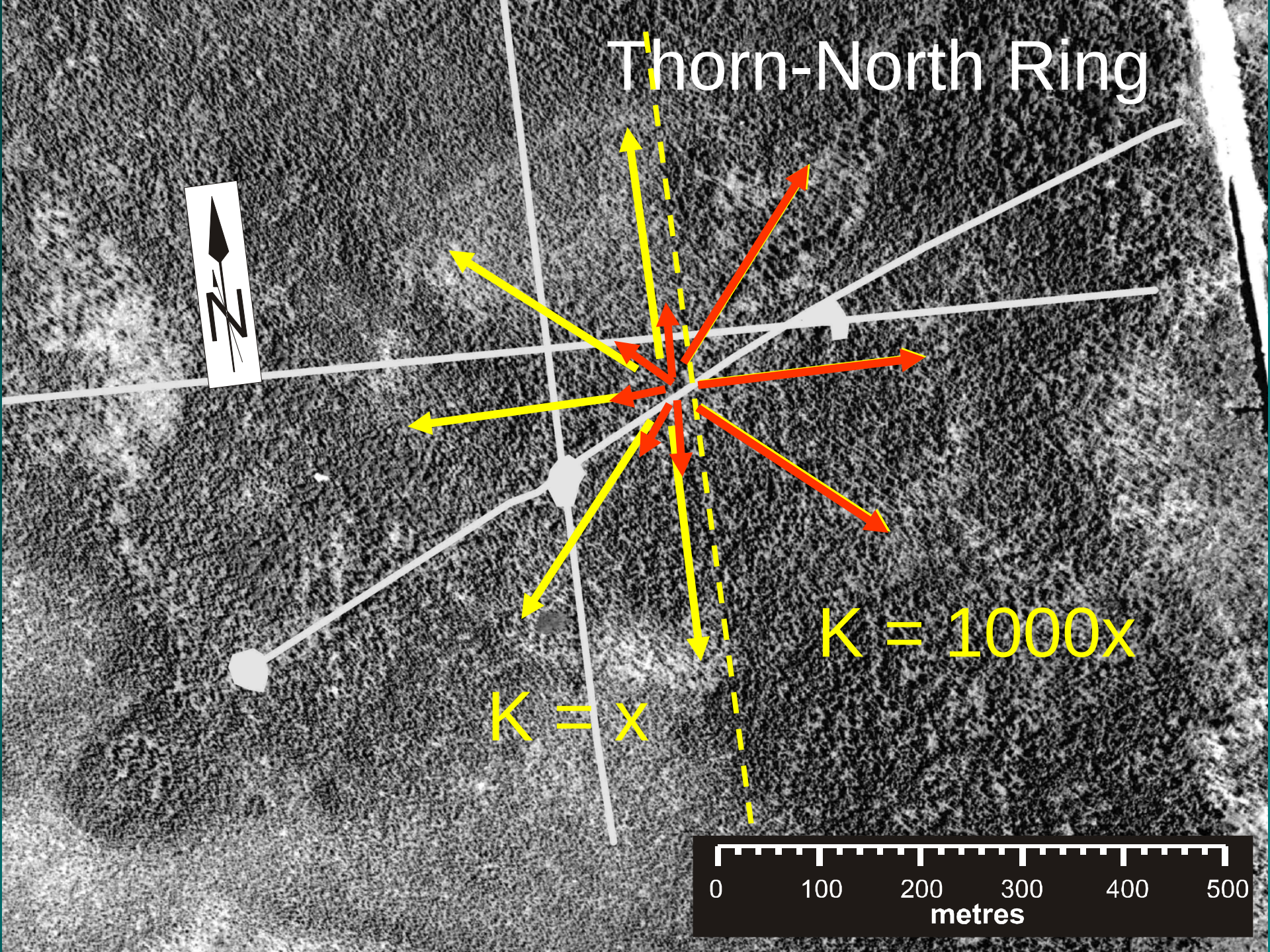
Inside Active Rim

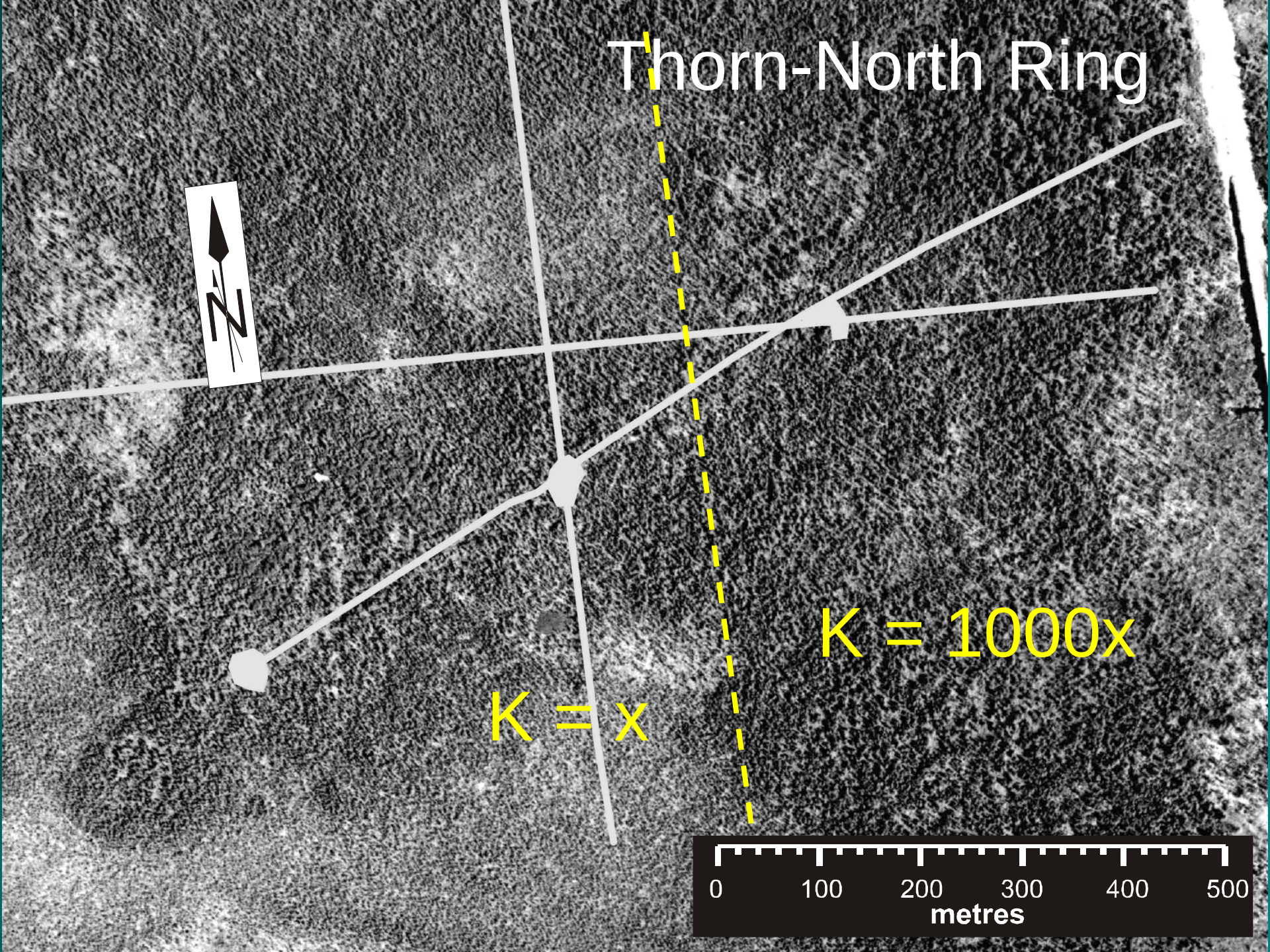
- Carbonate completely removed
- Only silicate clays remain
- Porosity increased



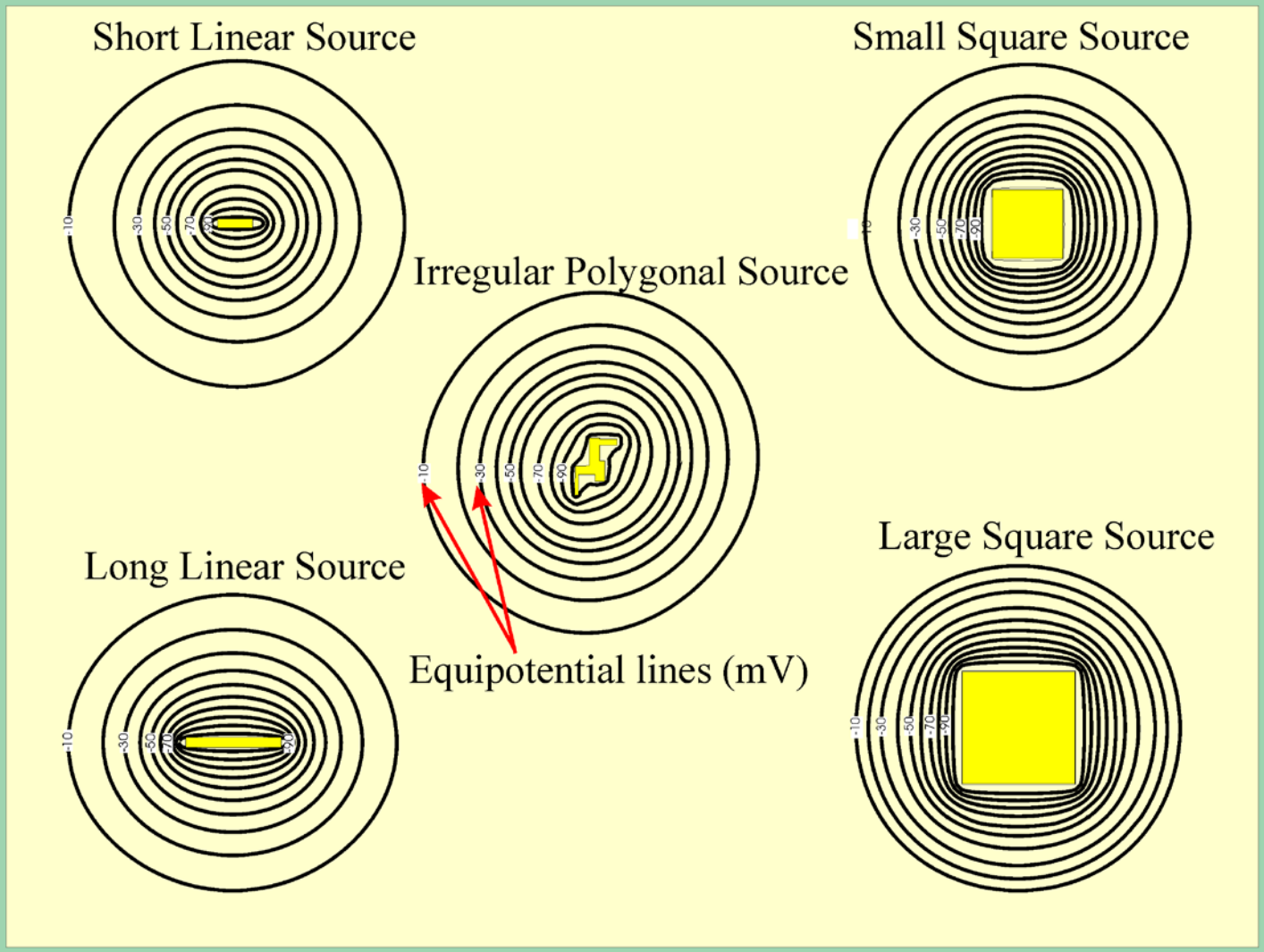
Adjacent to Active Rim

- Large amount of carbonate
- Euhedral crystals
- Porosity decreased
- Permeability decreased


Thorn-North Ring
N
K = 1000x
K = x
0
100
200
300
400
500
metres


Thorn-North Ring
N
K = 1000x
K = x
0
100
200
300
400
500
metres

Finite difference simulations of shape development



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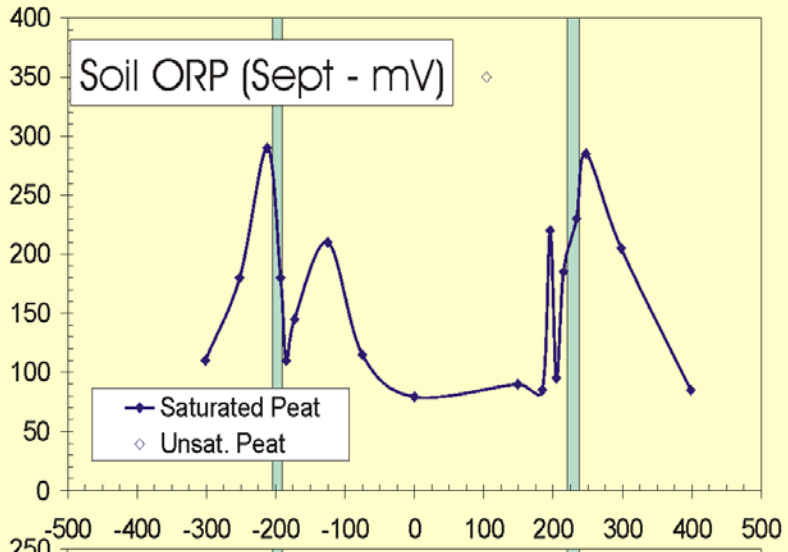
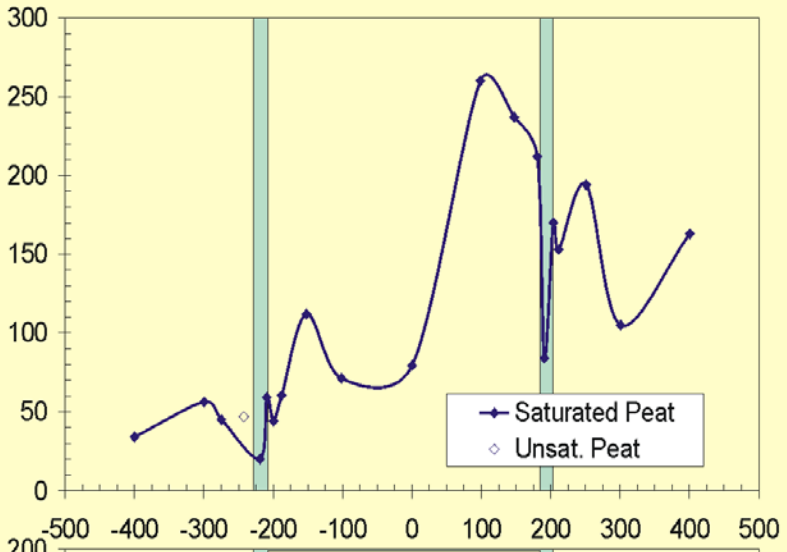
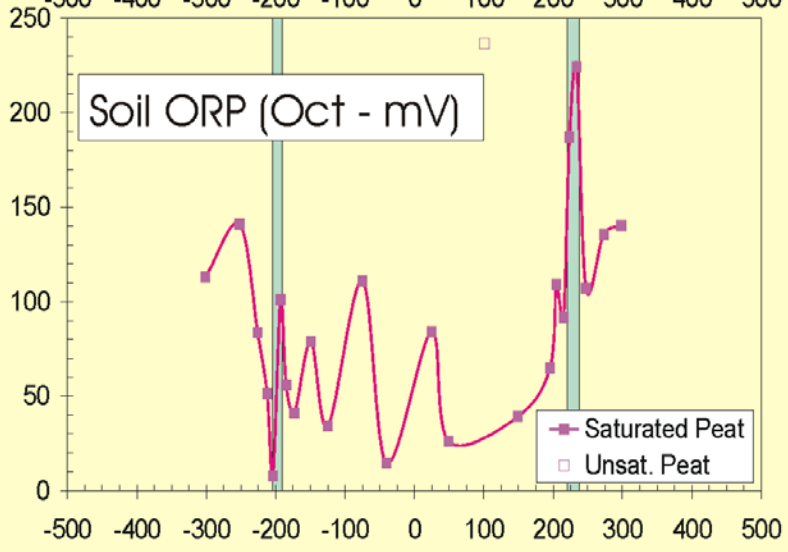
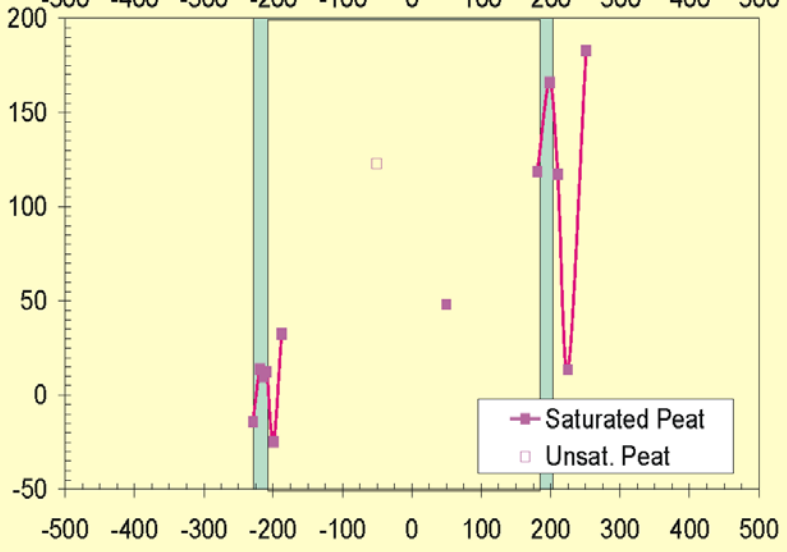
ORP at Bean Ring - 1999









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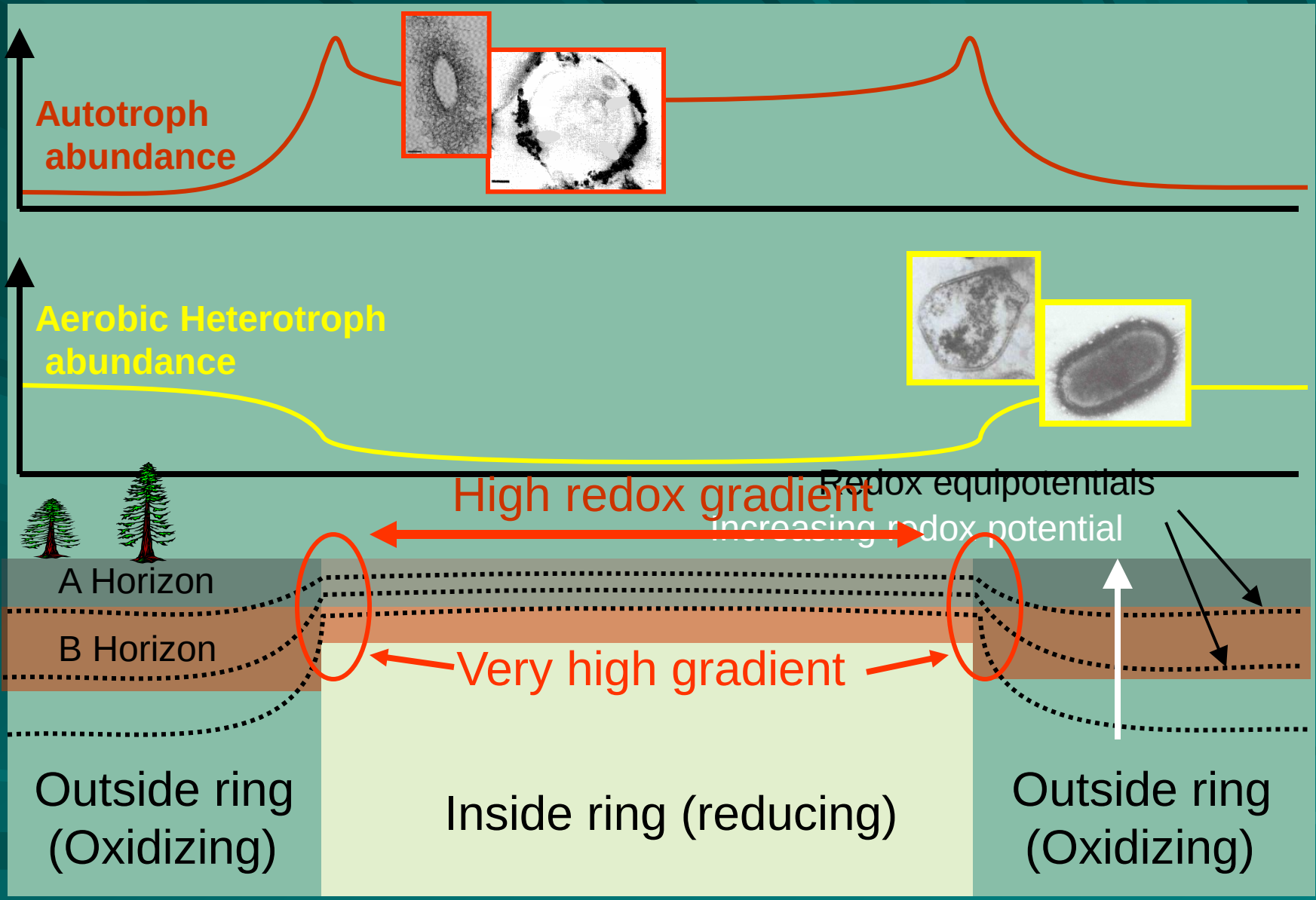
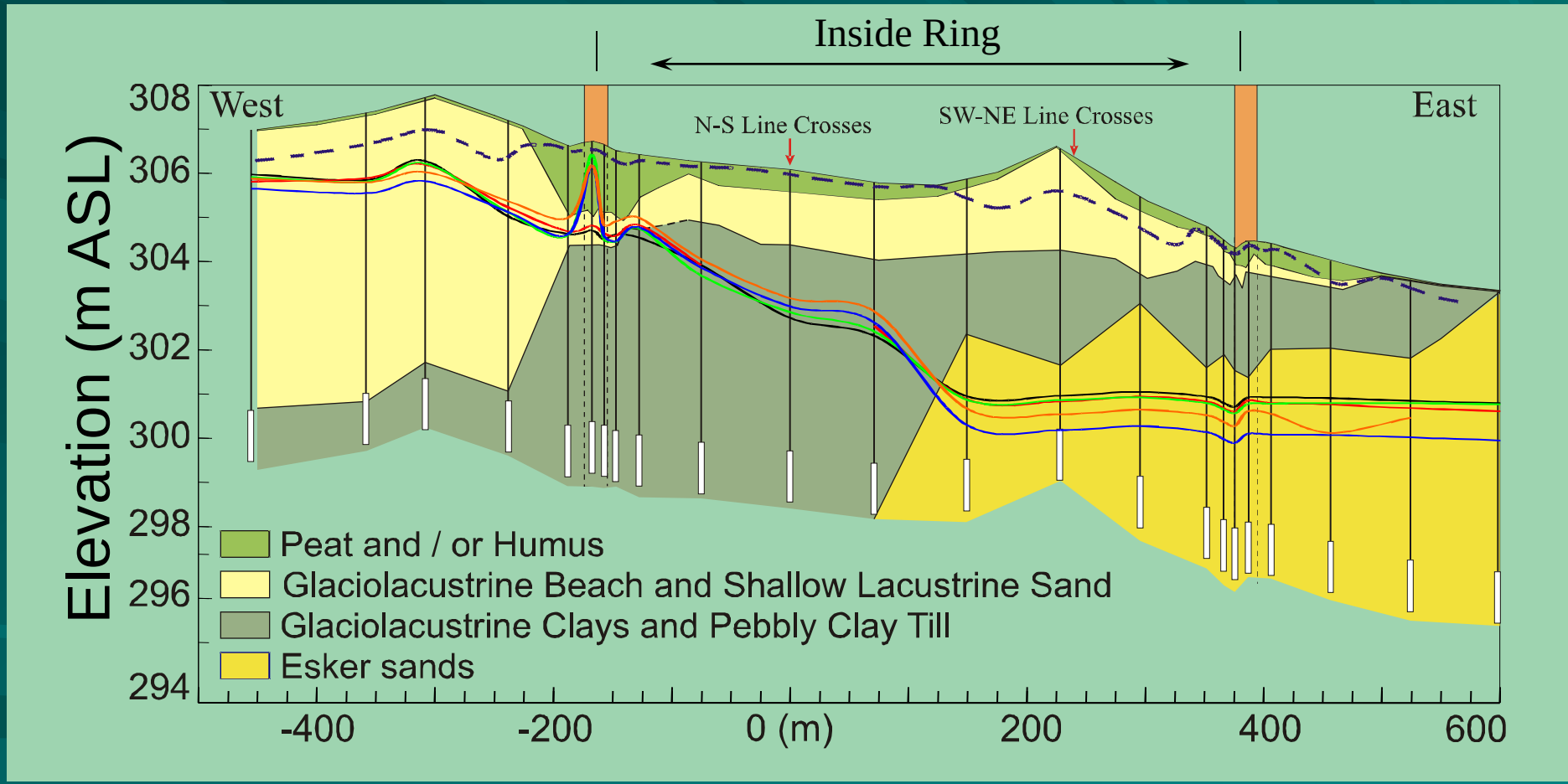
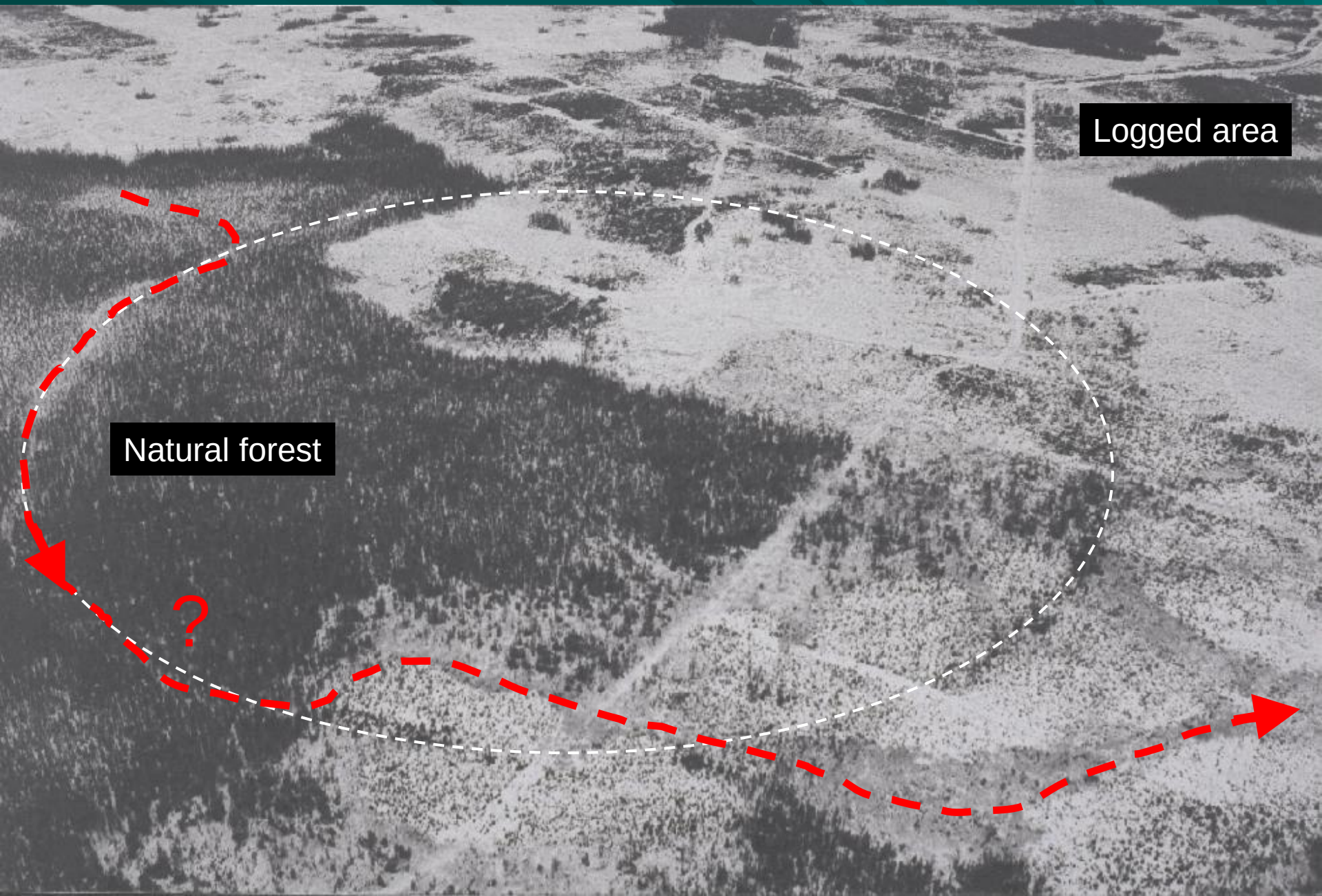


Water Table and Pieziometric Surface – Thorn North Ring



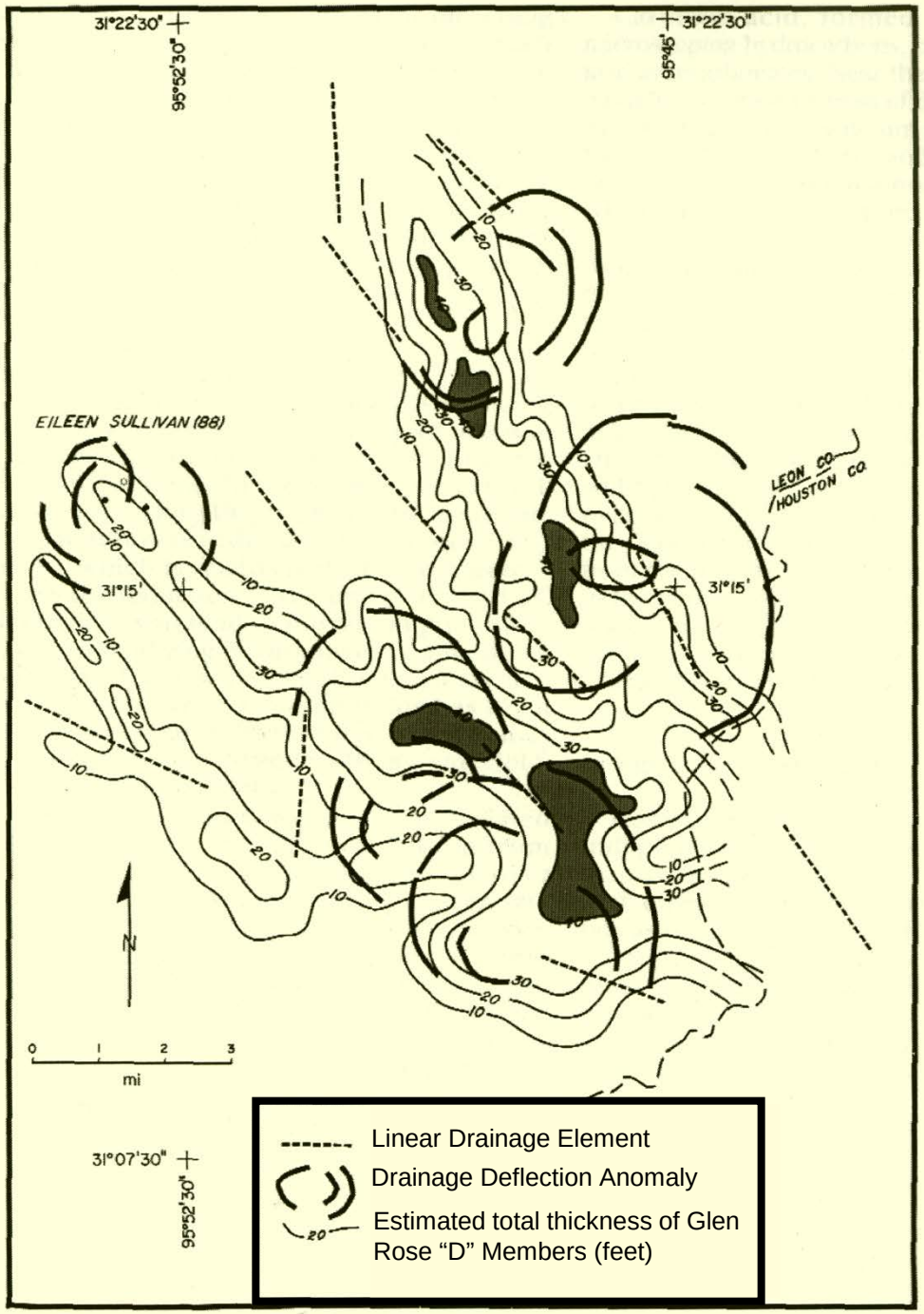
Drainage deflection



Drainage Deflection over Oil Reservoirs

Saunders et al., 1999
Figure 4

Attributed to resistive diagenetic carbonate over reservoir



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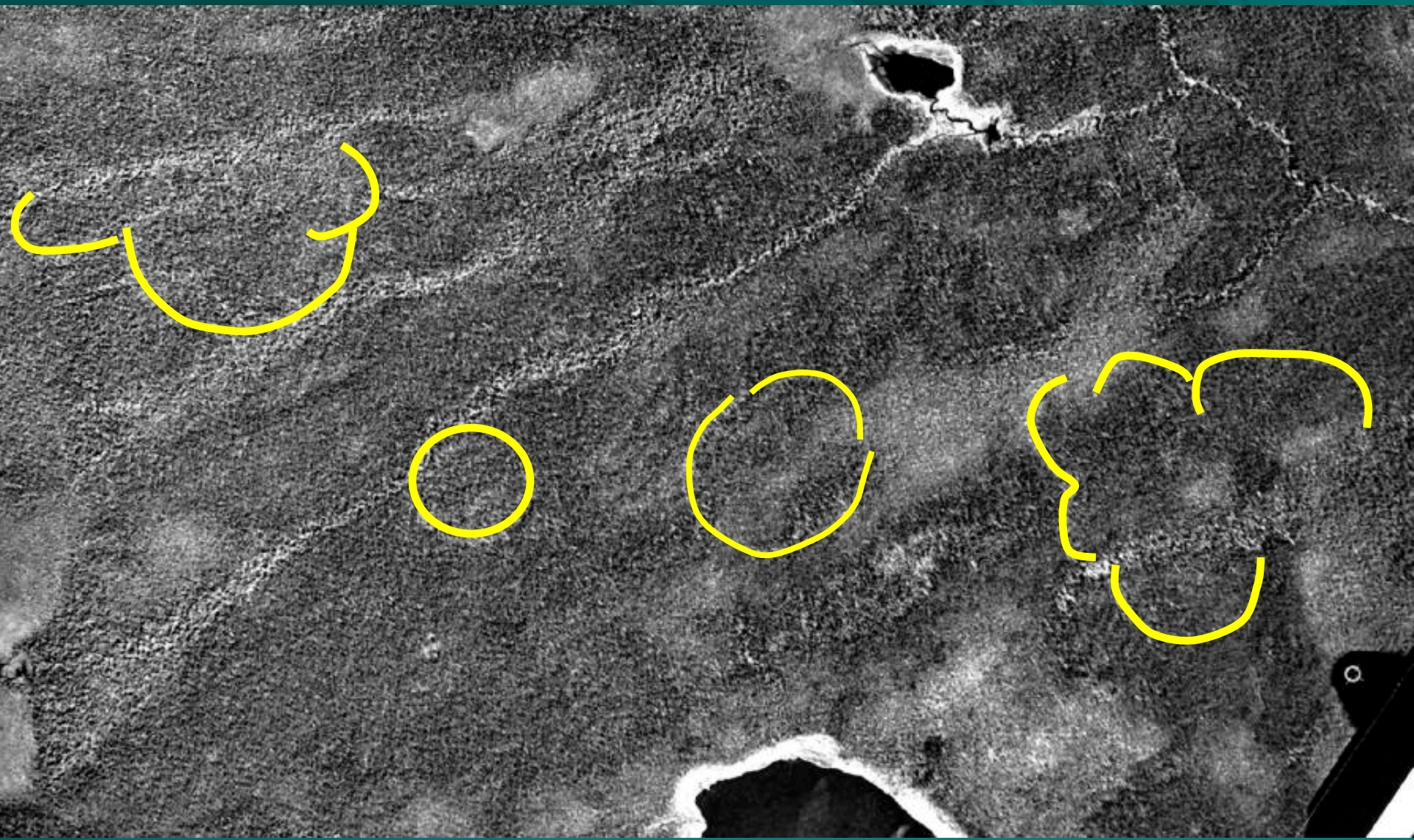
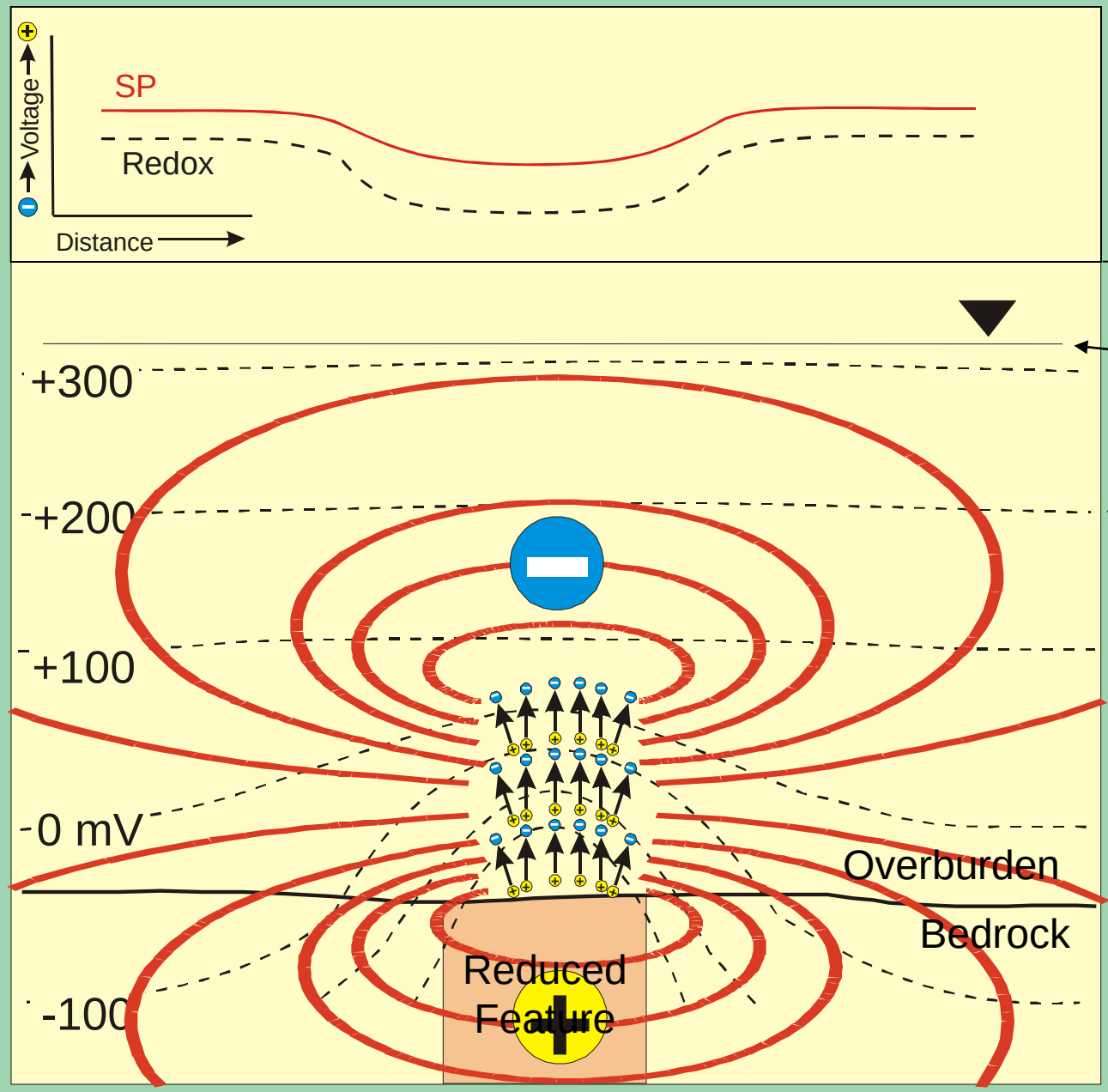
Coalescing Ring Segments

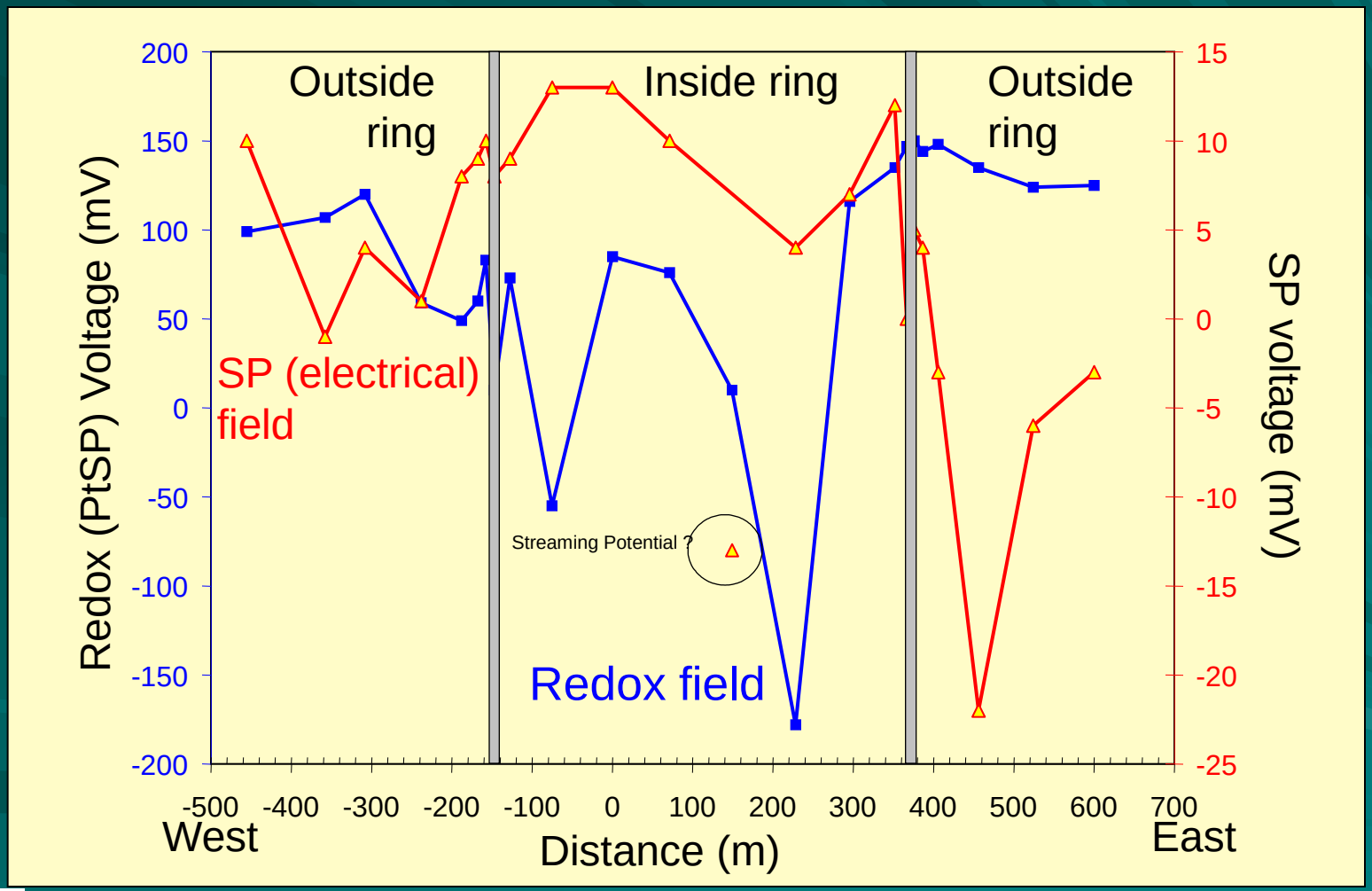


Redox-Induced Spontaneous Polarization



Redox and SP – Thorn-N Ring

(Measured down-hole in plastic monitoring wells)



Thorn-North ring, east-west transect

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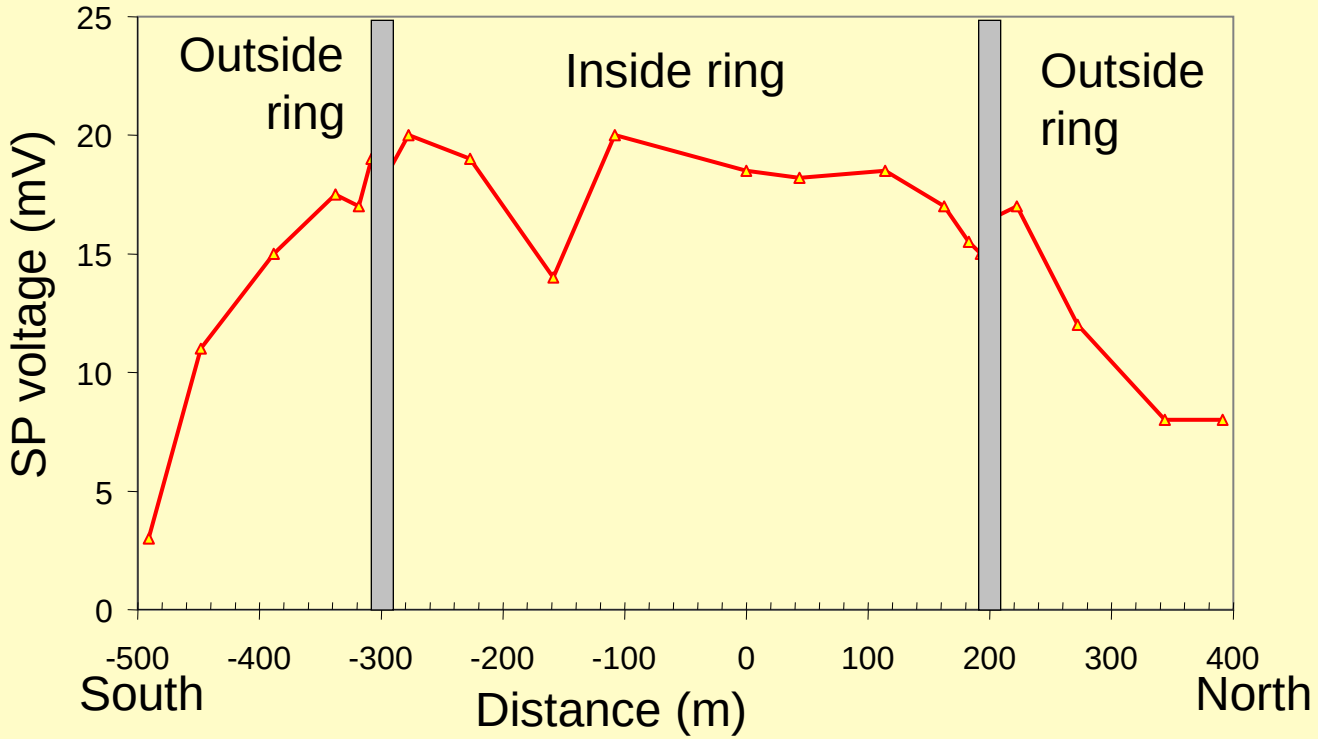
Down-hole SP – Thorn-N Ring



Thorn-North ring, south-north transect

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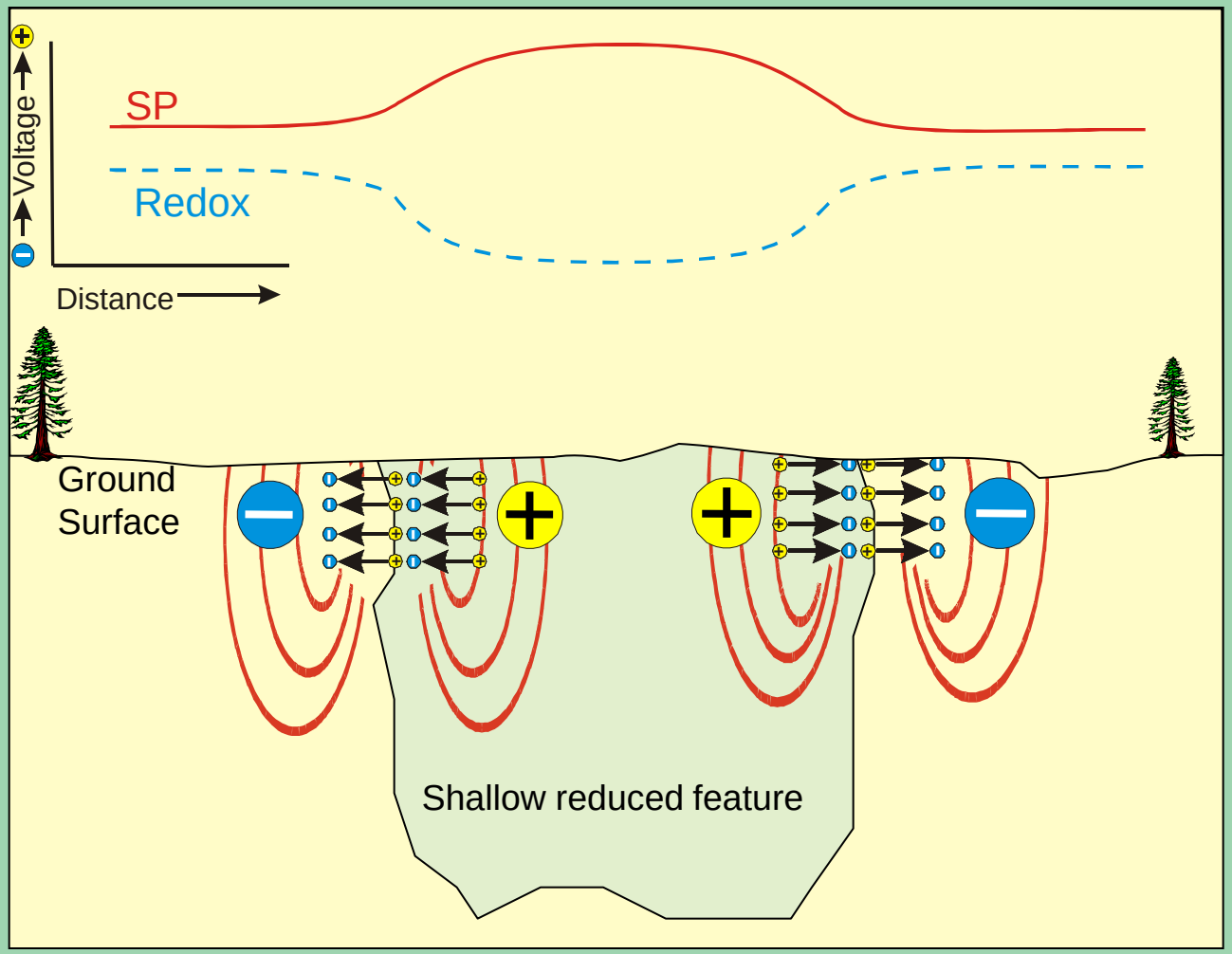
Spontaneous Polarization over a Shallow Reduced Feature



Polarity of constituent atoms

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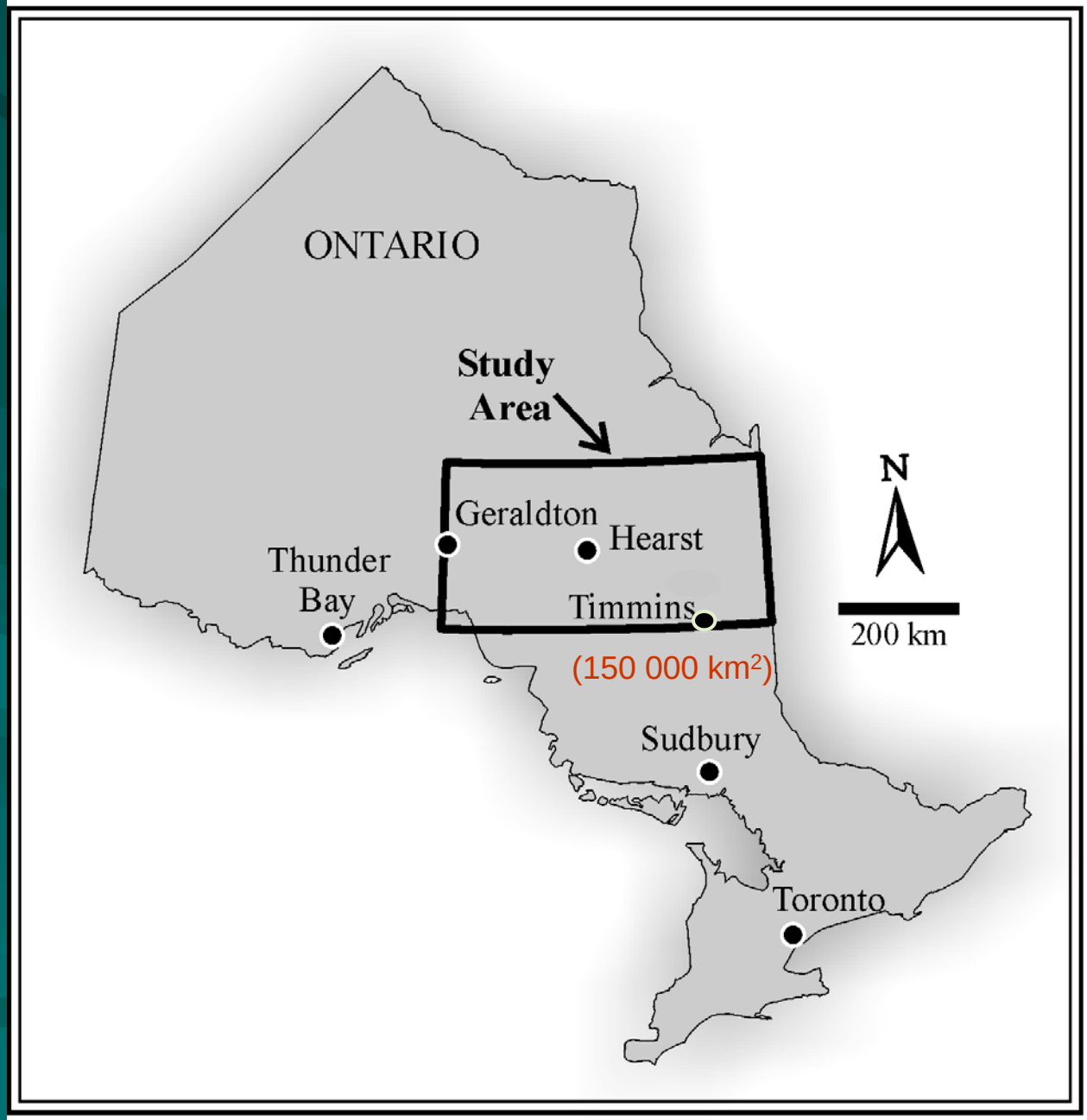
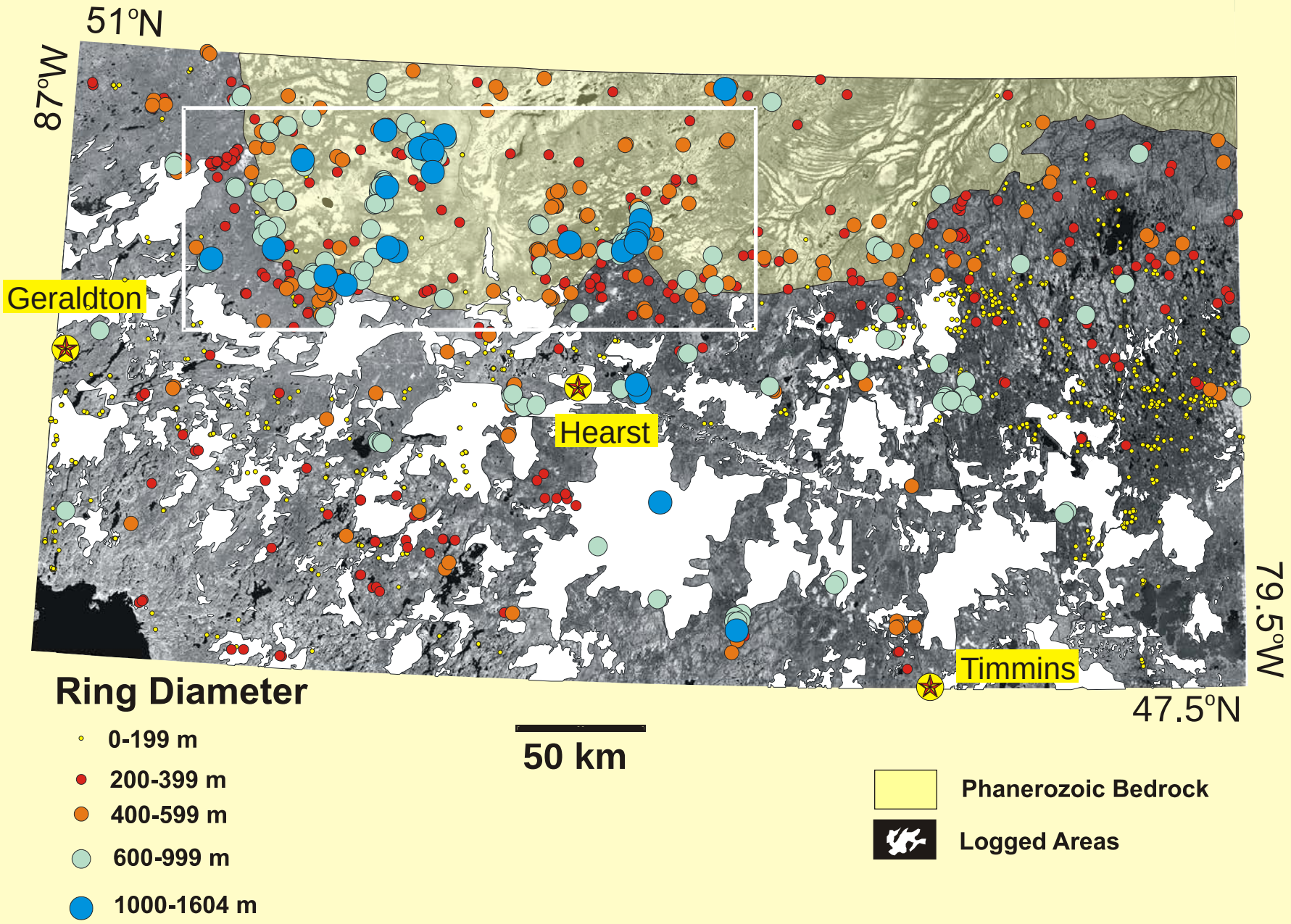
Ring Gas Study Area



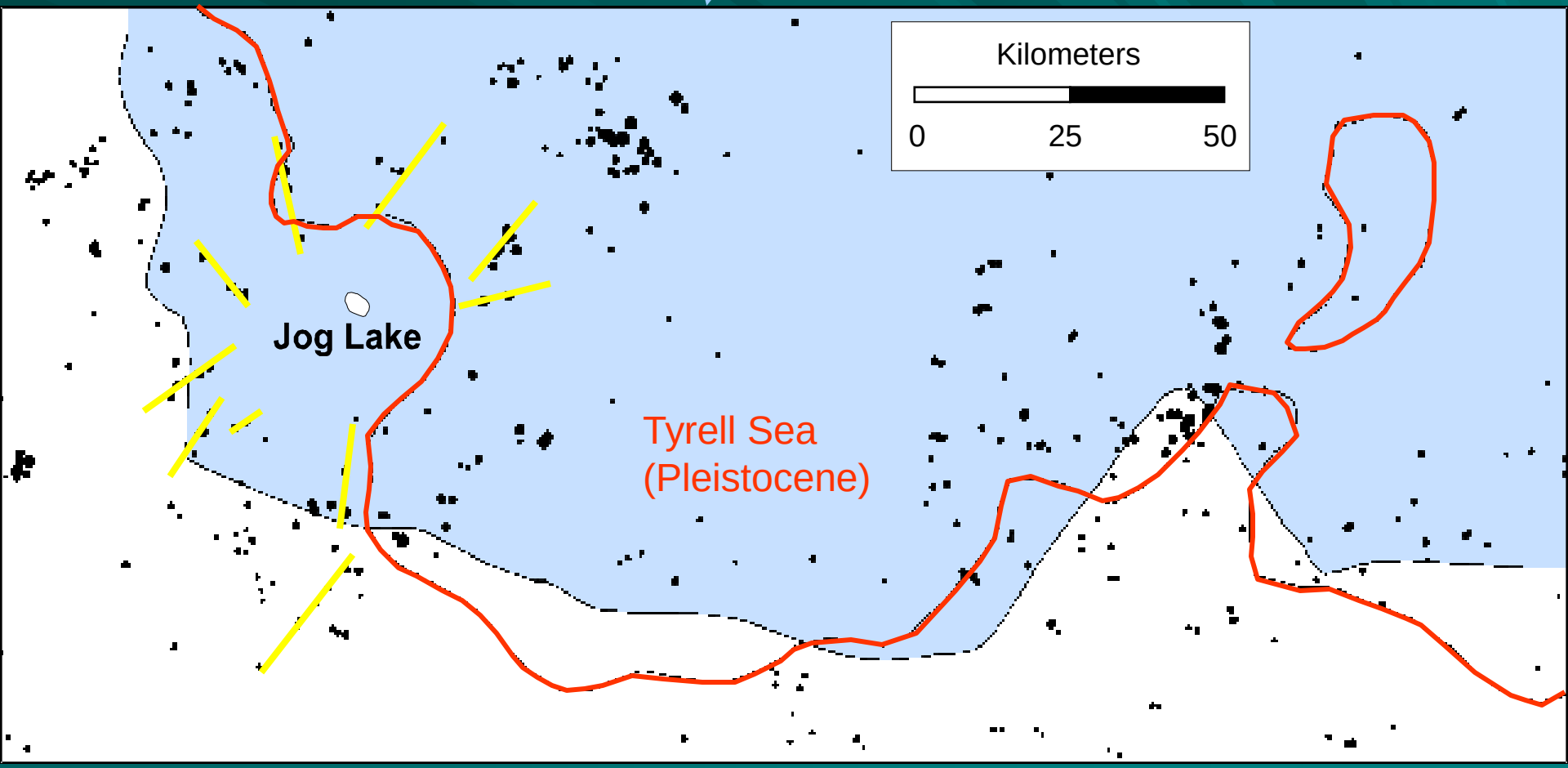
Hamilton et al., 2004

Ontario Geological Survey



Hamilton et al., 2004

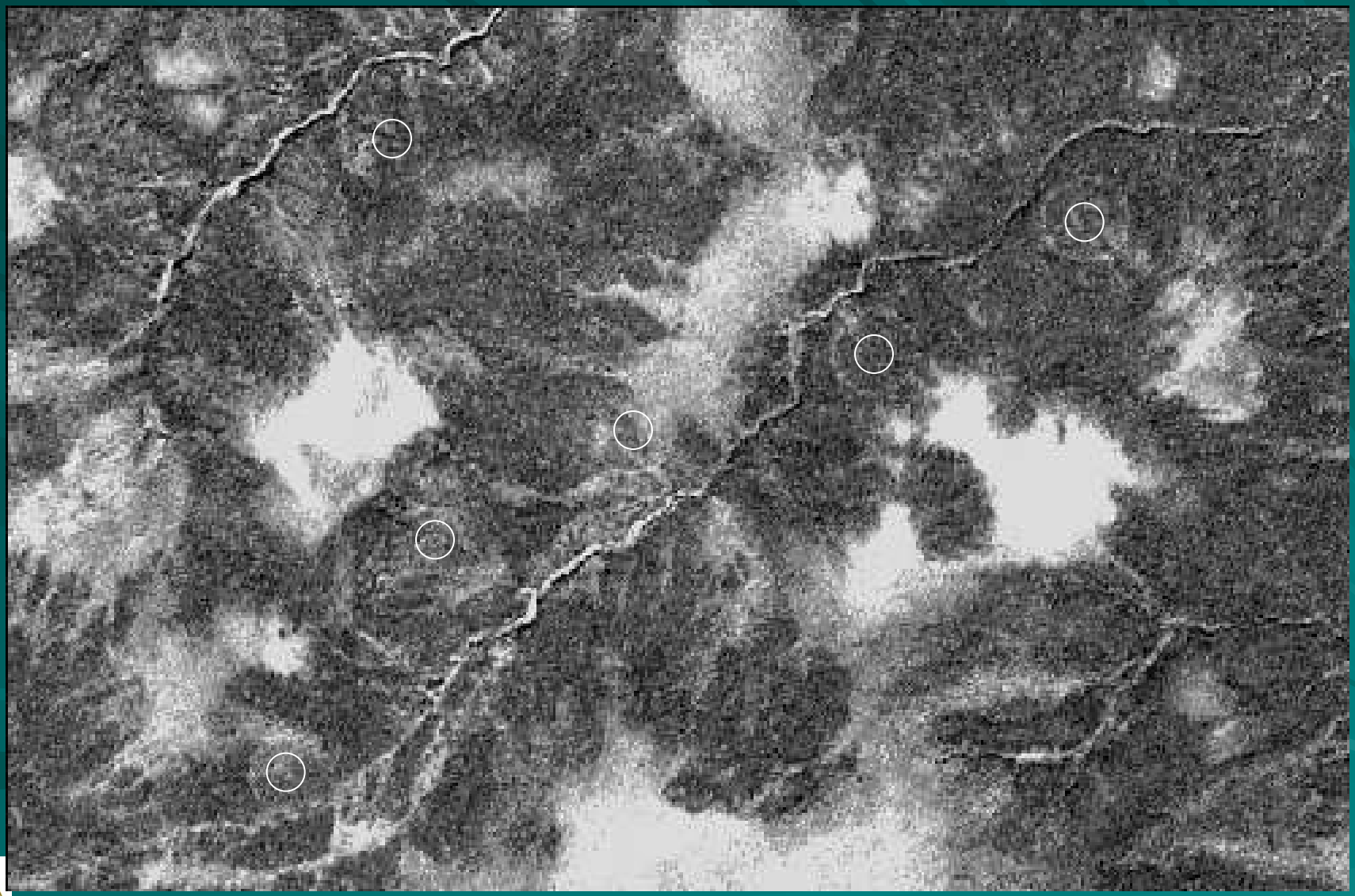
Geological Survey



Hamilton et al., 2004

Ontario Geological Survey

Linear pattern of rings SW of Jog Lake



2 km

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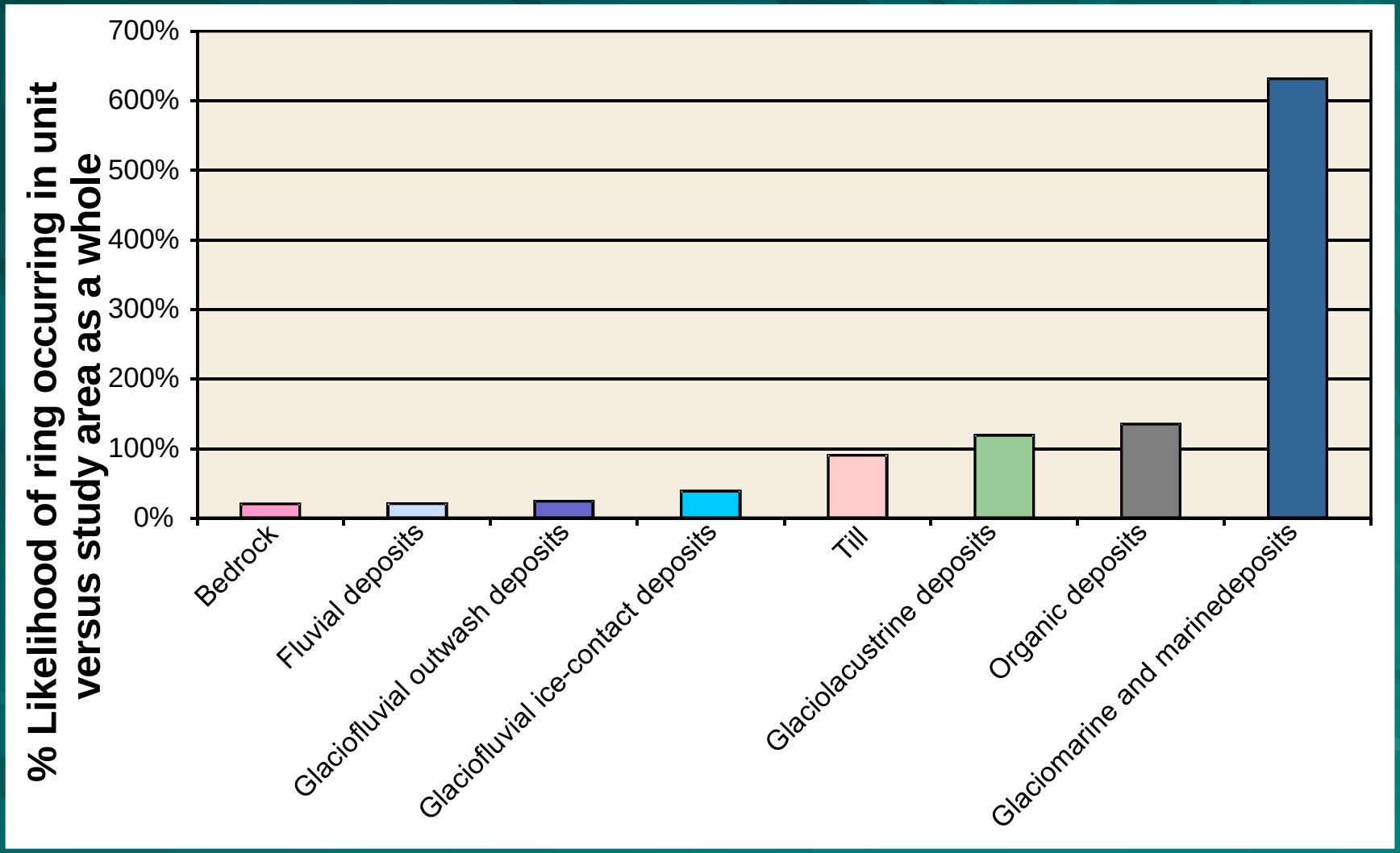
Jog Lake



Hamilton et al., 2004

Ontario Geological Survey

Methane Measurements by Spectral Absorption

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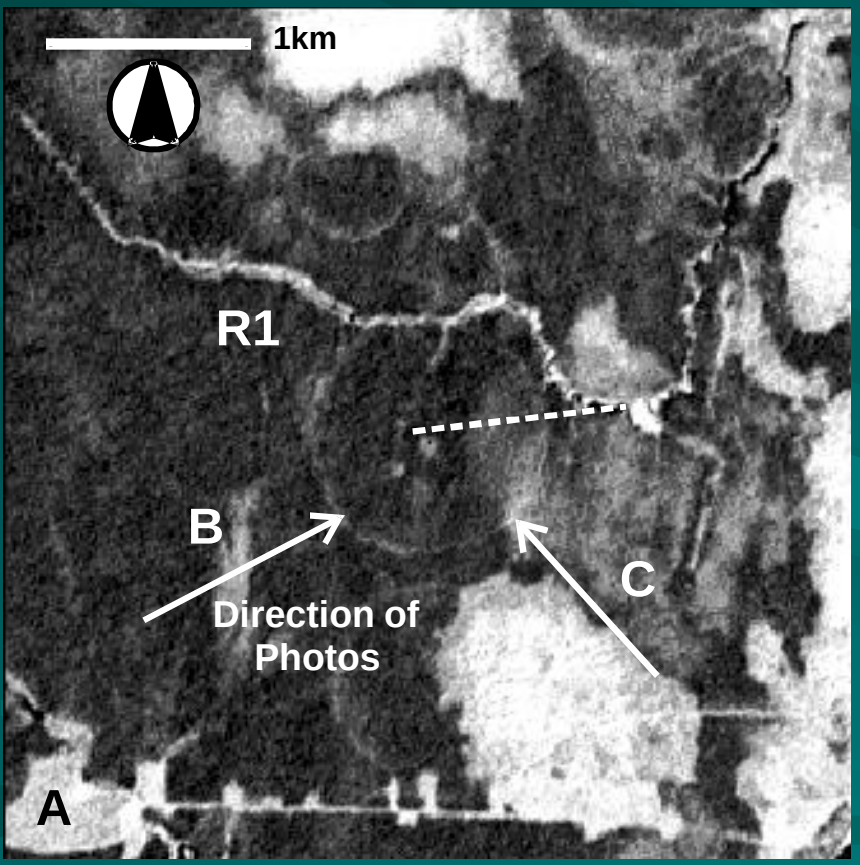
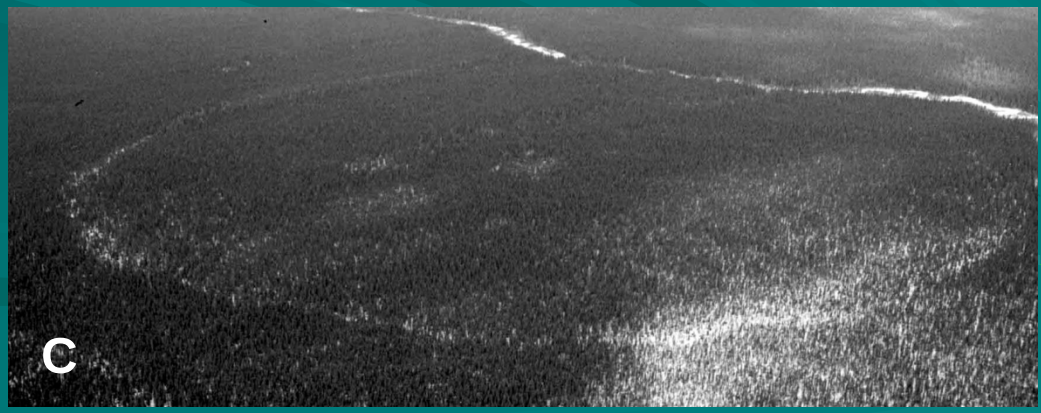
R1 – Cheechka Ring, Hearst



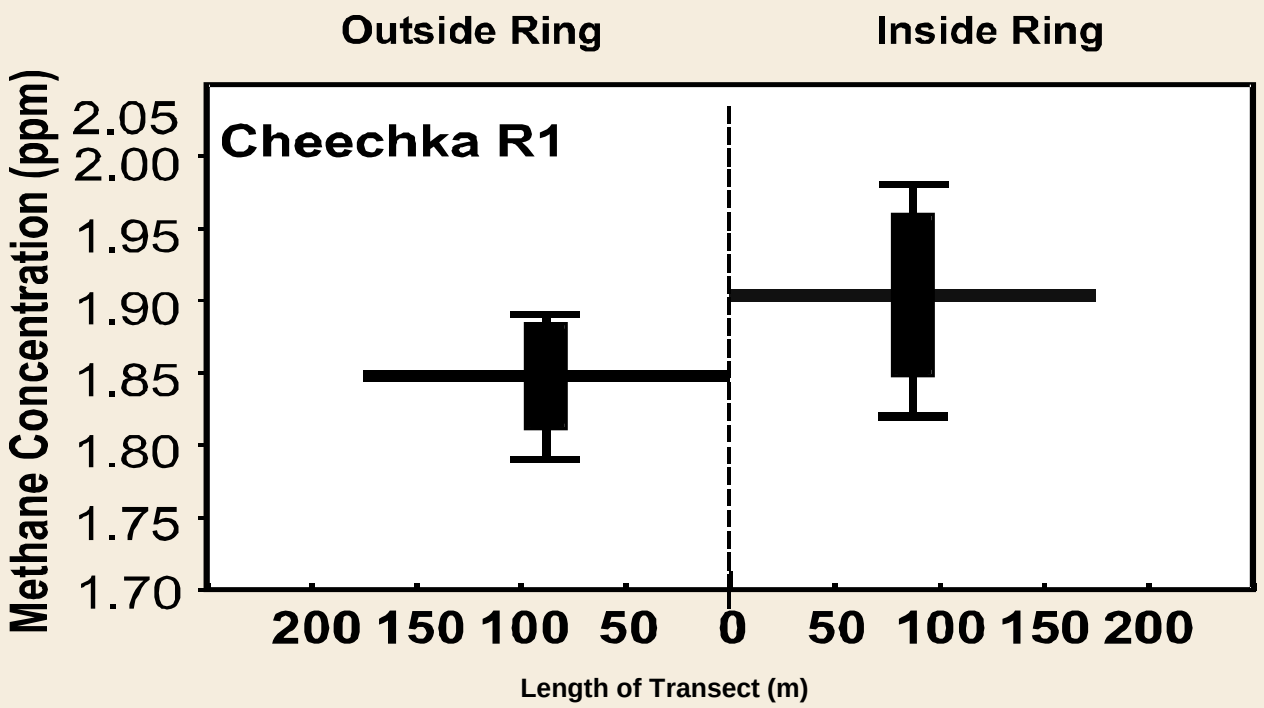


Hamilton et al., 2004

Ontario Geological Survey

Laser Gasfinder Data

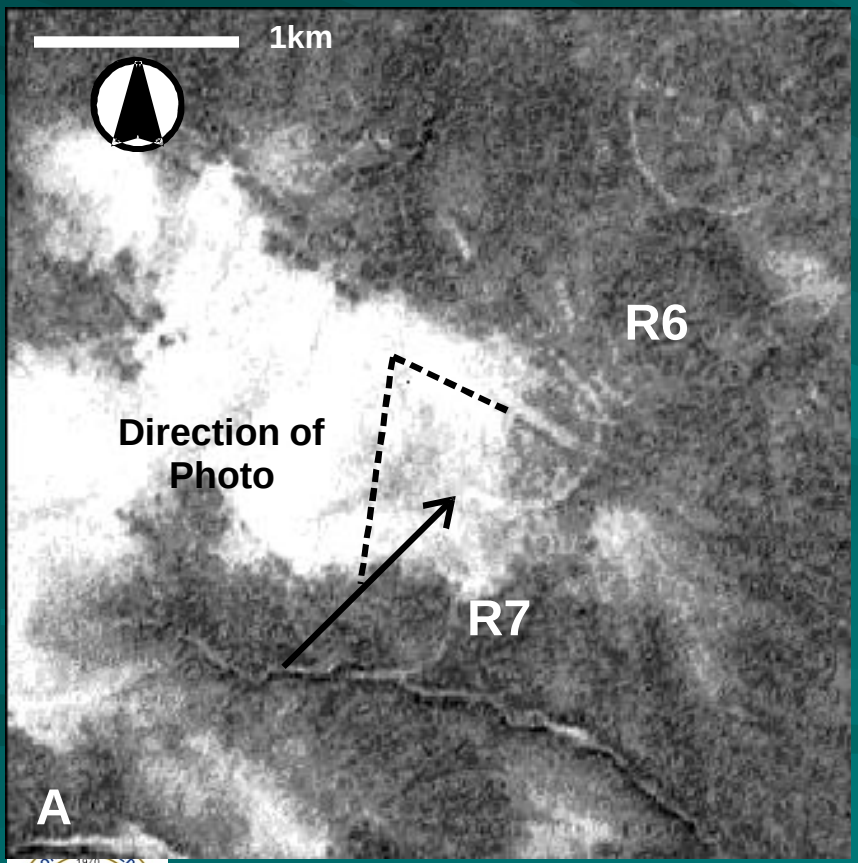
Mean, Maximum, Minimum and 1 Standard Deviation



Hamilton et al., 2004

Ontario Geological Survey

R6 – Northwest of Jog Lake



Hamilton et al., 2004

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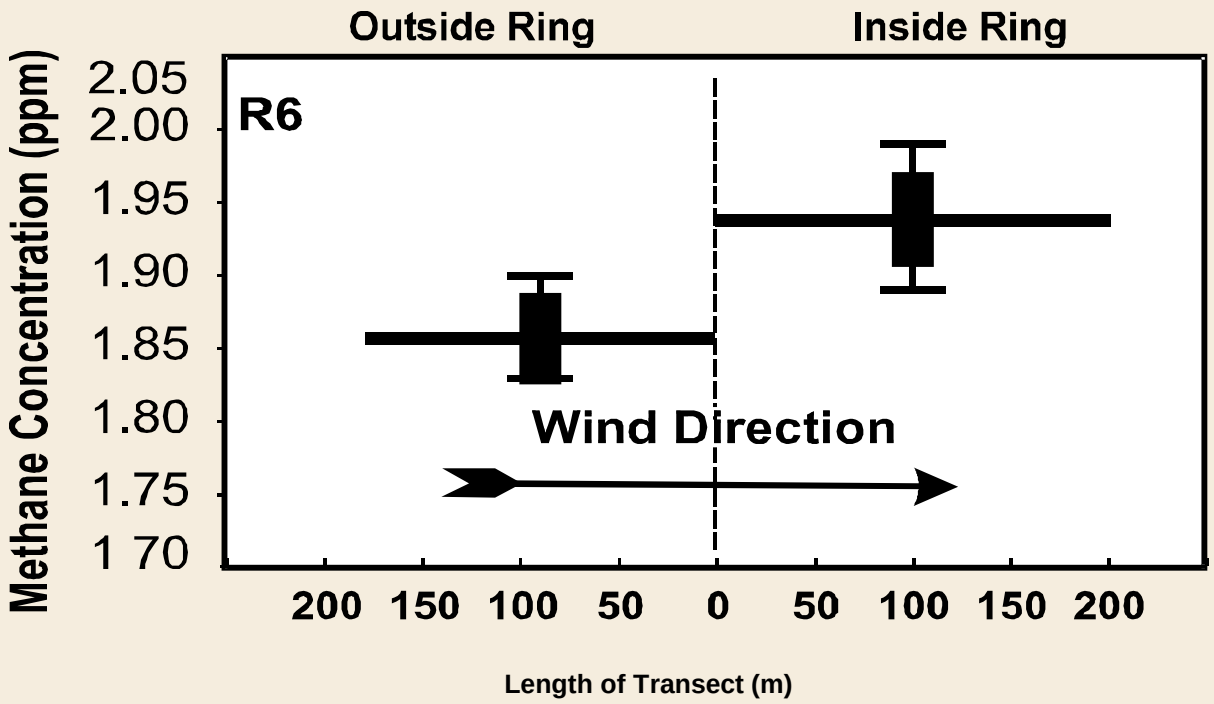
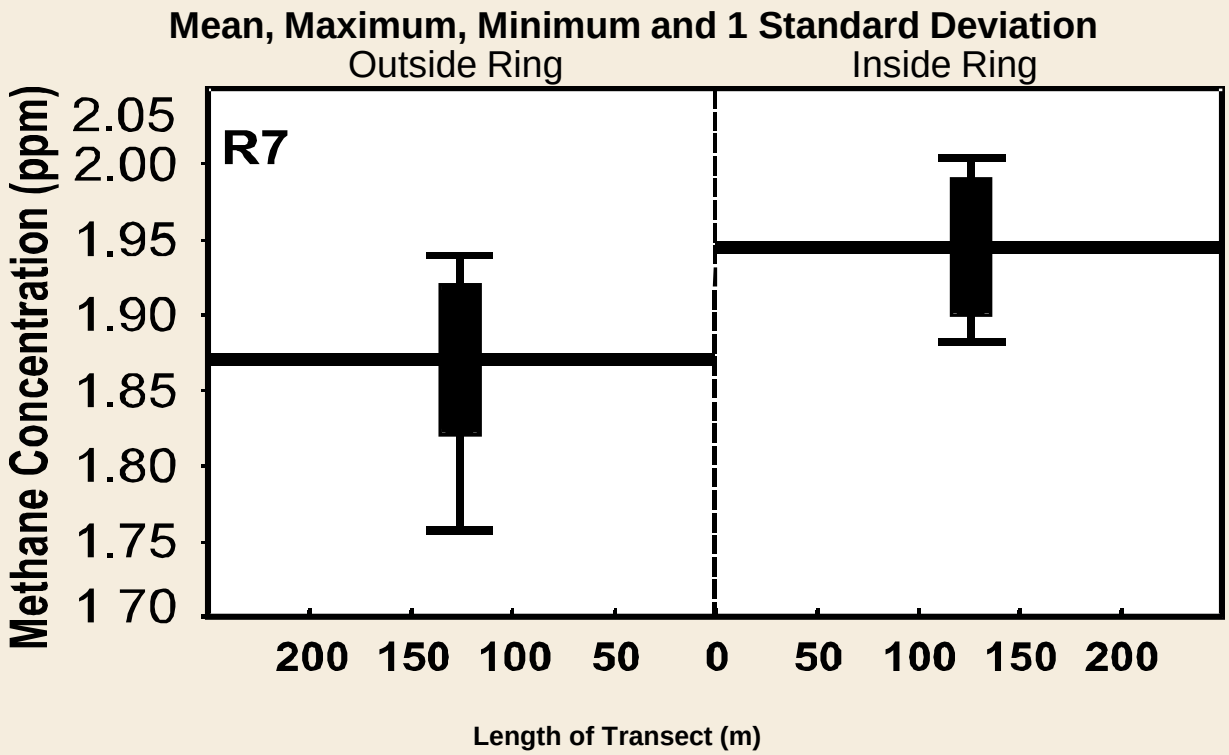


Hamilton et al., 2004

Ontario Geological Survey

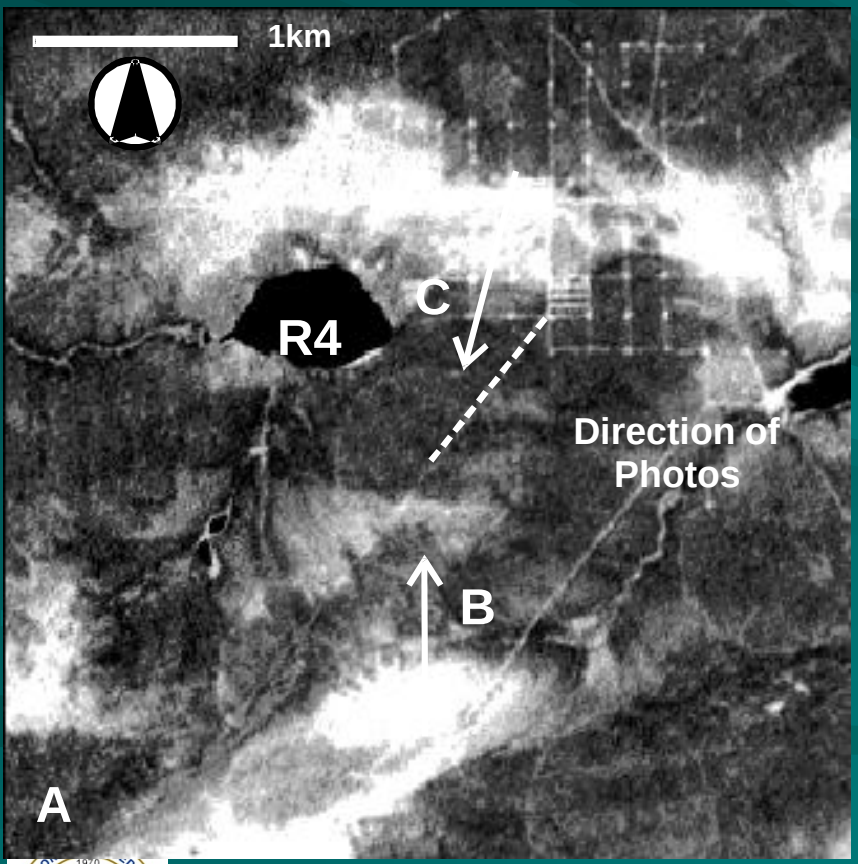
Laser Gasfinder Data



Hamilton et al., 2004

Ontario Geological Survey

R4, Martison Lake Carbonatite



Hamilton et al., 2004

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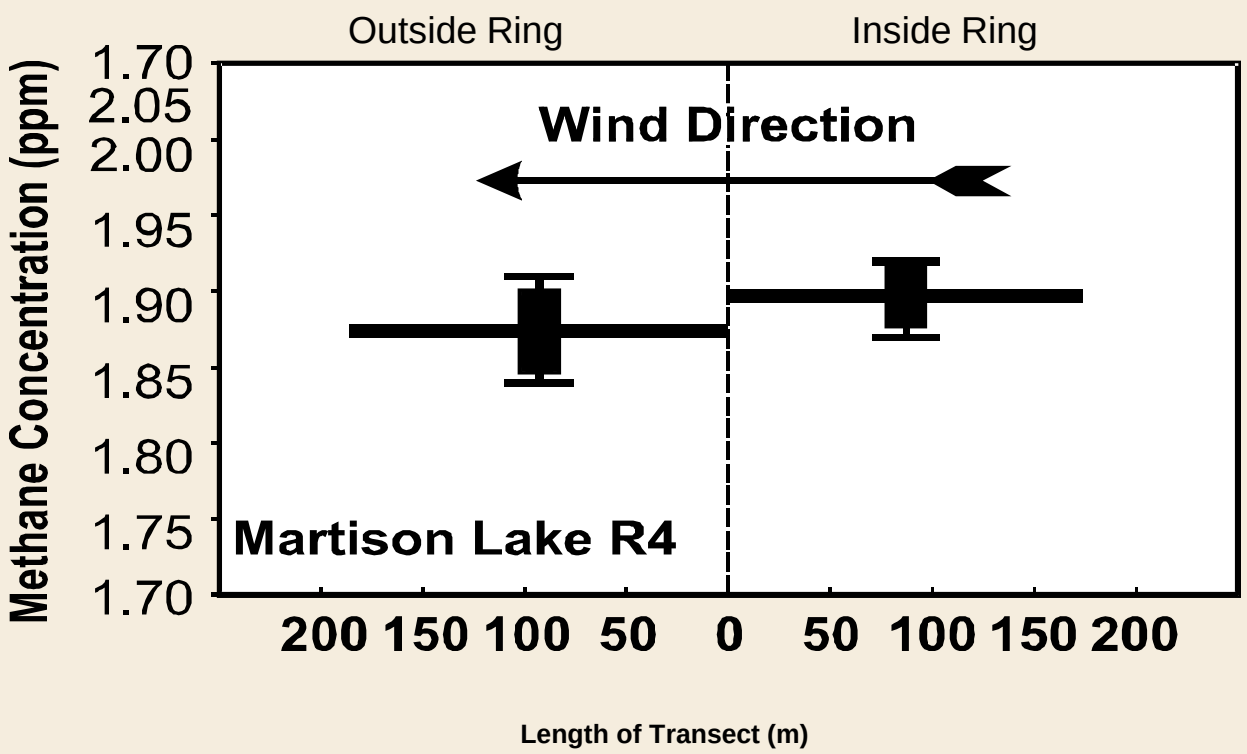
Laser Gasfinder Data



Hamilton et al., 2004

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Source of Methane
Carbon Isotope Results

sample	CH_4	CO_2	1000 ln α (CO_2-CH_4)	Isotopic temperature (^{o}C)*
BE01-shallow	-82.0	-12.1	73.4	13
BE01-deep	not sufficient	-12.1		
BE-11	-79.6	-12.5	70.3	22
BE-16	-87.4	-11.1	80.3	-3.9
BE-21	-75.8	-14.1	64.7	39

Hamilton et al., 2004

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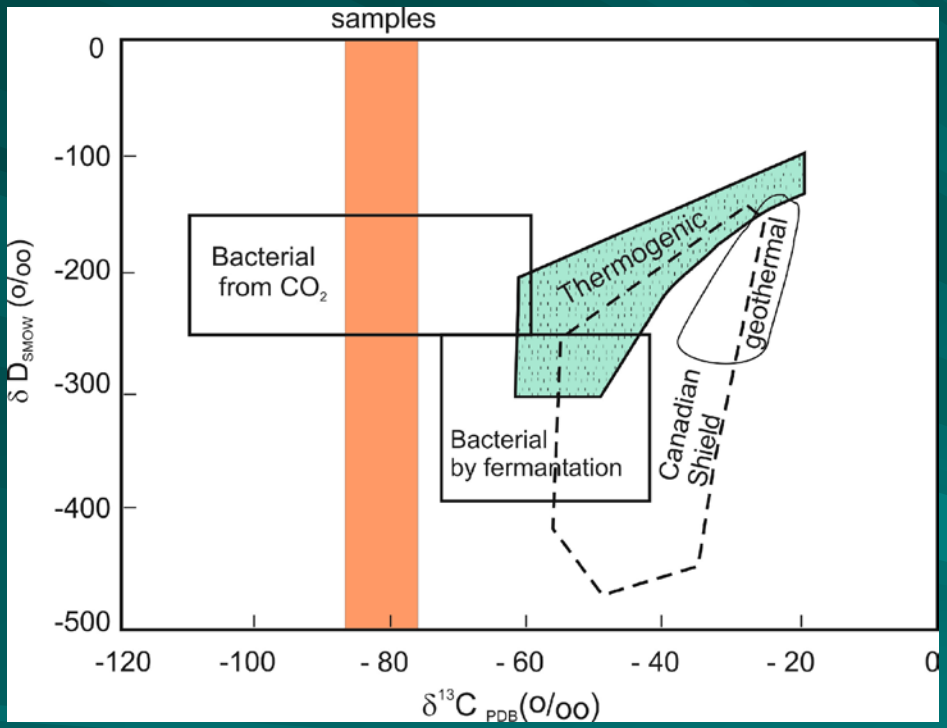

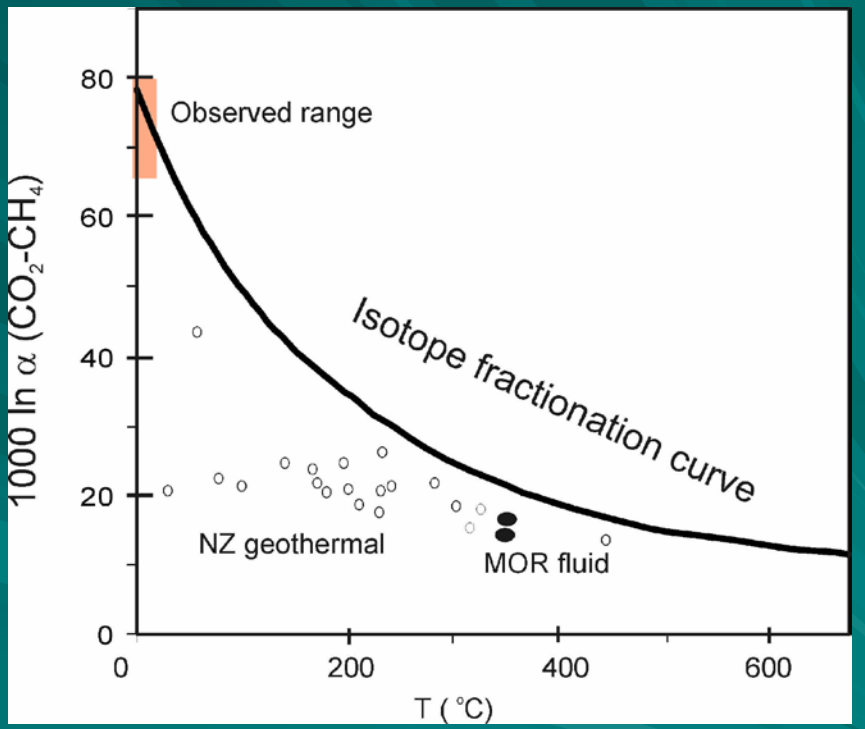

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Summary

1. Rings are large centres of negative (redox) charge
2. They are static geological features that form similarly to “reduced chimneys” over mineral deposits and oil and gas reservoirs
3. They are known to form over oil, gas and H_2S but could conceivably form over any negative redox anomaly (e.g. kimberlites, sulphides)
4. Many (>80%) in Ontario are natural gas-sourced
5. A large proportion are biogenic related to Tyrell-Sea glaciomarine sediment but others may have a deeper bedrock source, due to structural control

Implications

1. The very fast formation of these features and large movement of mass and charge points to previously unheard-of transport processes
2. The ring structures offer a unique opportunity to study reduced chimneys in a shallow surface environment inexpensively and in much greater detail than could be accomplished over these other features.
3. Due to the large number of rings and the great size of some, they represent a possible “unconventional” source of natural gas.