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**Geological Survey of Canada
Scientific Presentation 168**

Thorncliffe Formation: conceptual model of a buried channel-fan aquifer system, greater Toronto region, Ontario

D.R. Sharpe, C.E. Logan, and A.-M. Pugin

2024

Canada

Presented at the Ontario Groundwater Geoscience Open House presented by the Ontario Geological Survey, the Geological Survey of Canada, and Conservation Ontario

Date presented: February 2024

Publications in this series have not been edited; they are released as submitted by the author.
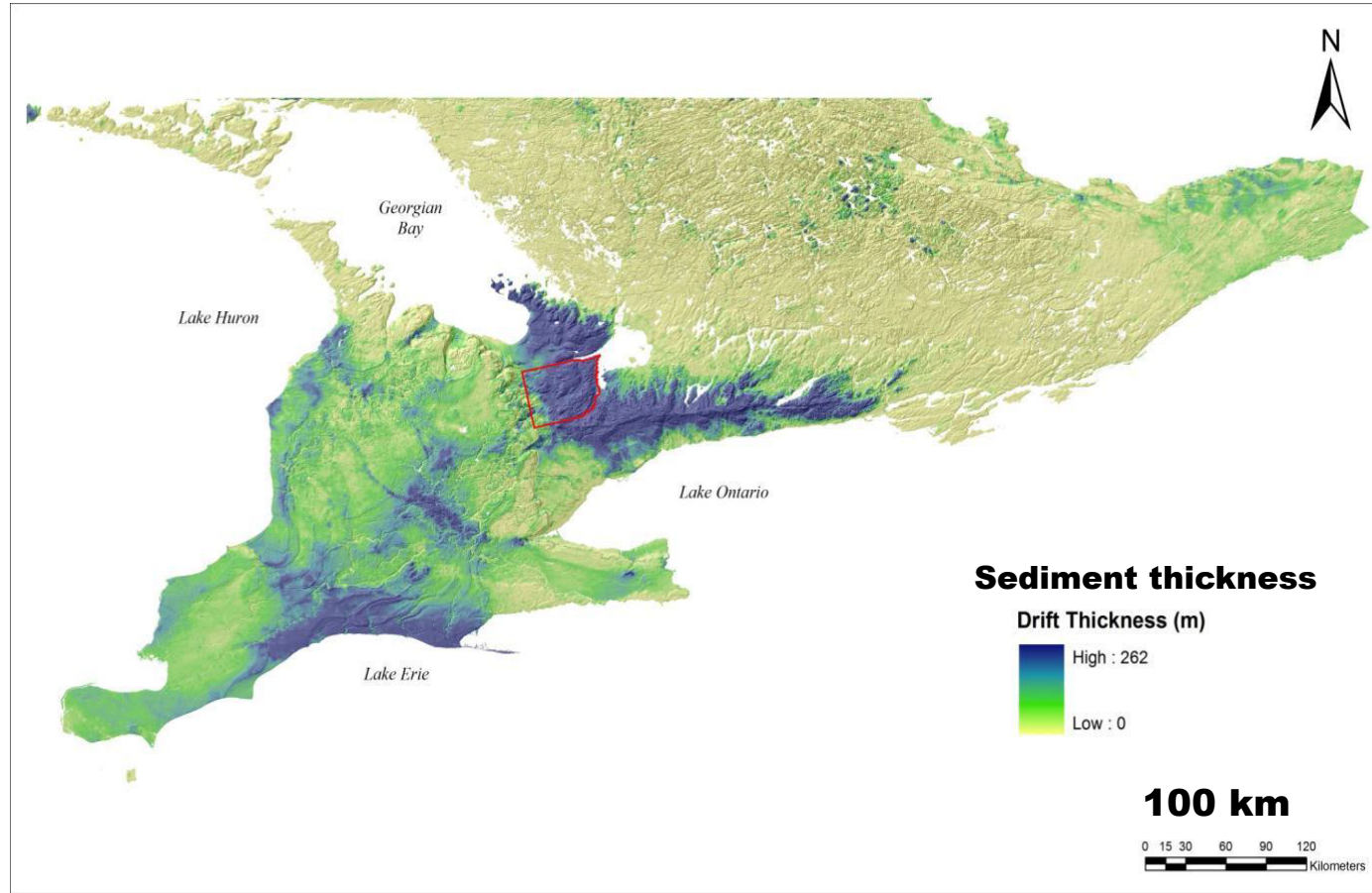
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Thorncliffe Formation:
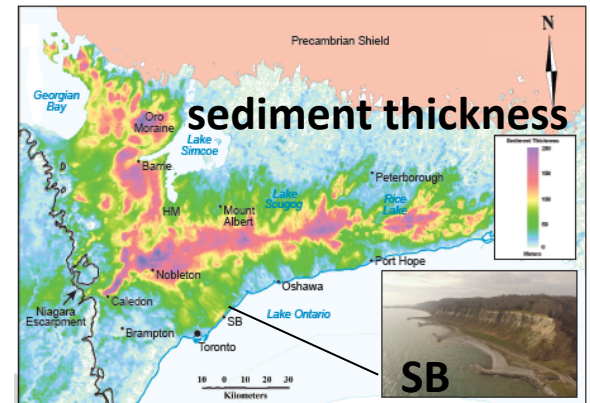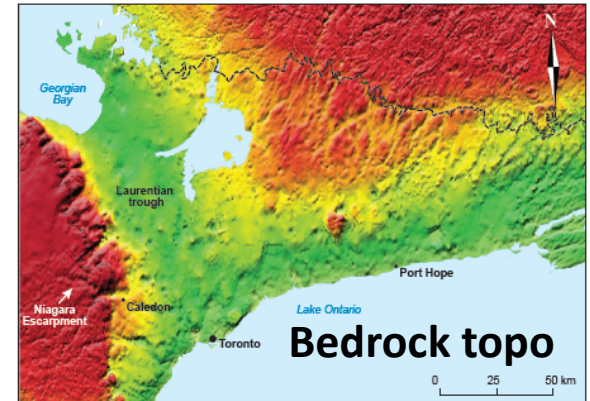## conceptual model of a
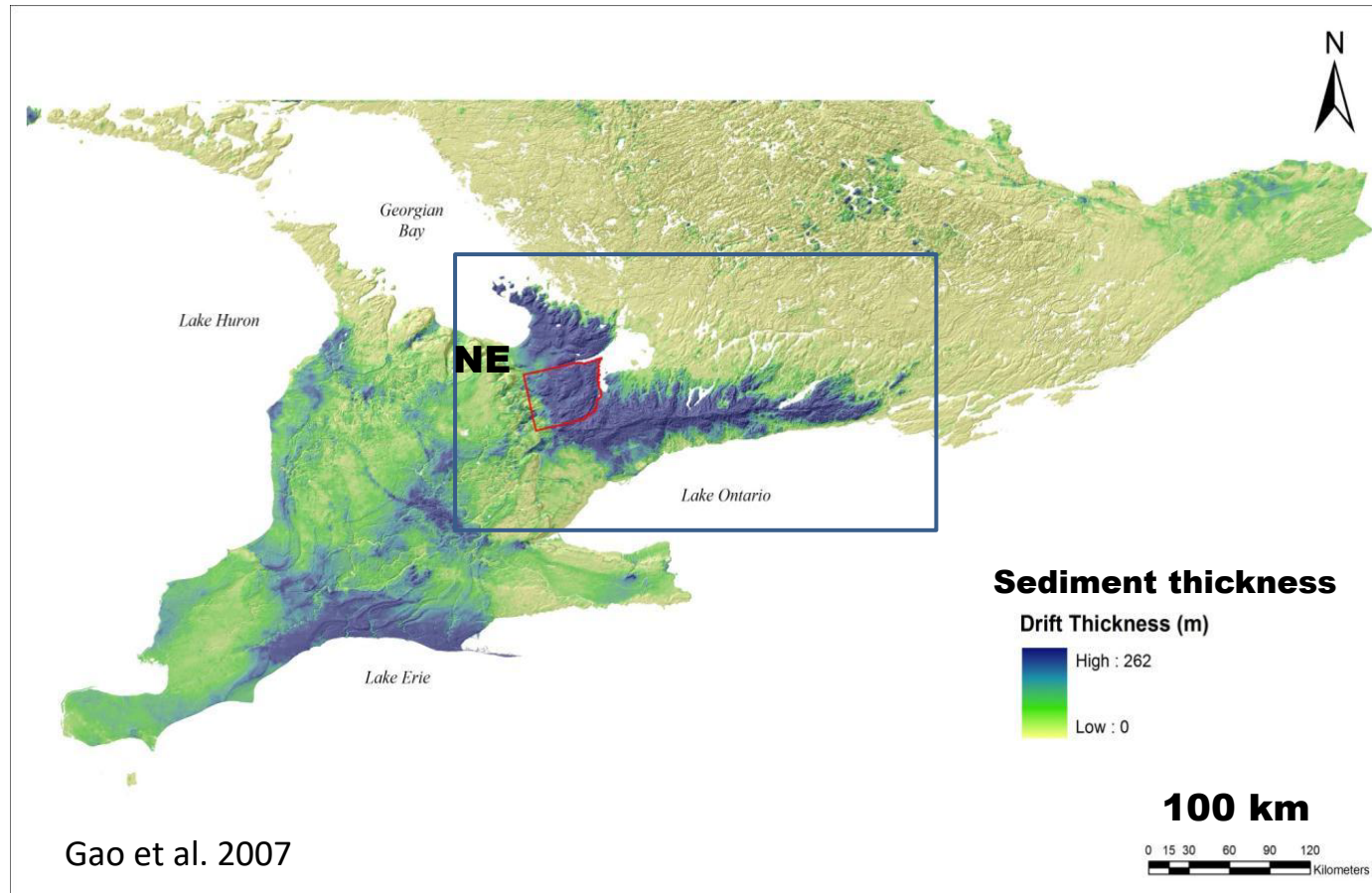## buried channel-fan aquifer system

Sediment thickness

Drift Thickness (m)

High : 262

Low : 0

100 km

0 15 30 60 90 120 Kilometers

David Sharpe
Charles Logan
Andre Pugin

Geological Survey of Canada

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Regional context

Sediment thickness

Drift Thickness (m)

High : 262

Low : 0

100 km

Gao et al. 2007

Bedrock topo

sediment thickness

SB

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Thorncliffe Formation within thick basin sediments
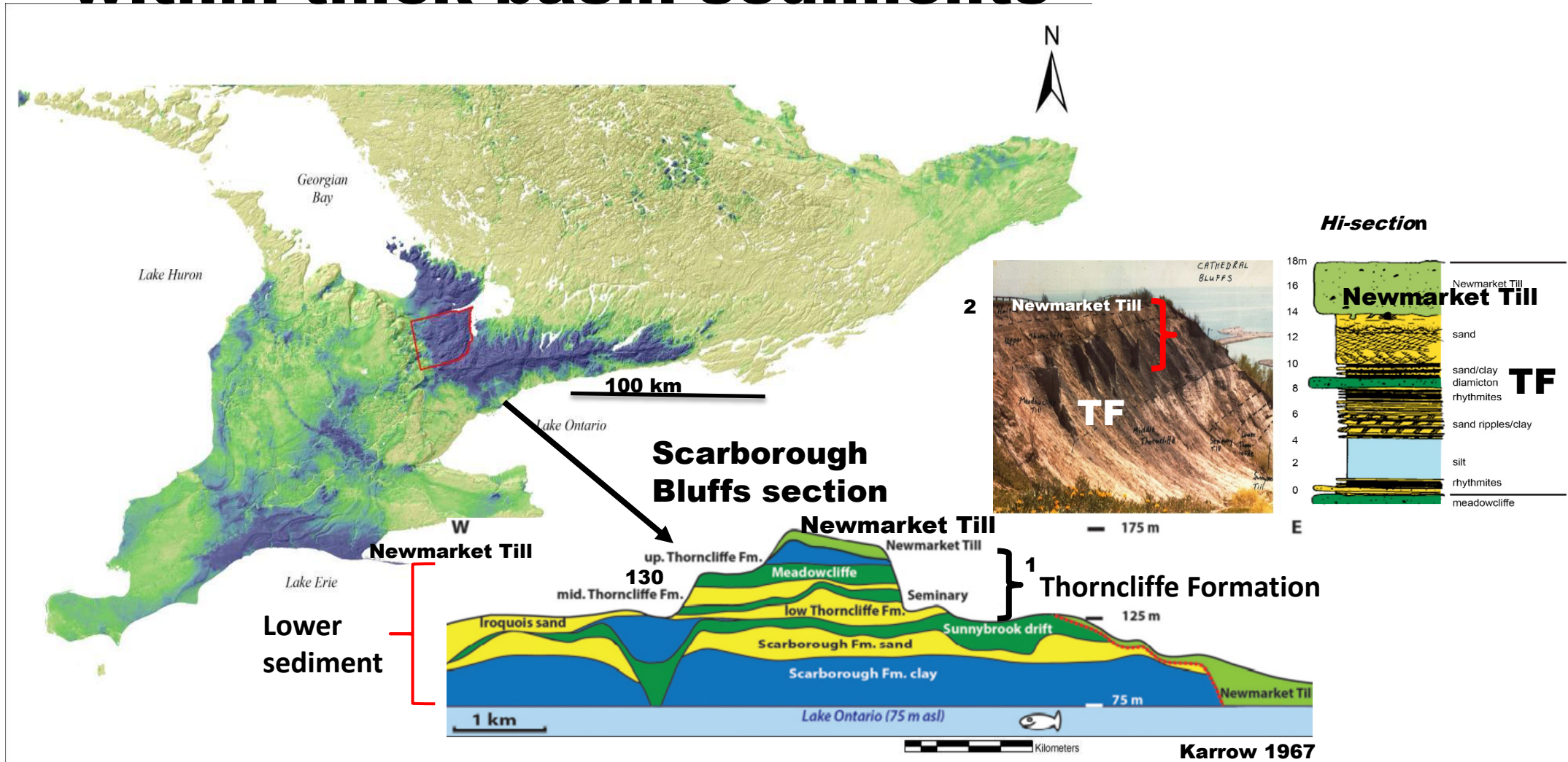
Scarborough Bluffs section

Lower sediment

Newmarket Till

Hi-section

Newmarket Till

TF

Thorncliffe Formation

Karrow 1967

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Lower sediment thickness
(includes Thorncliffe Fm)

Stratigraphy

Lower sediment isopach map (<NT)

Logan et al. 2020

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Regional Stratigraphic Framework

Russell et al. 2003

Surface geology

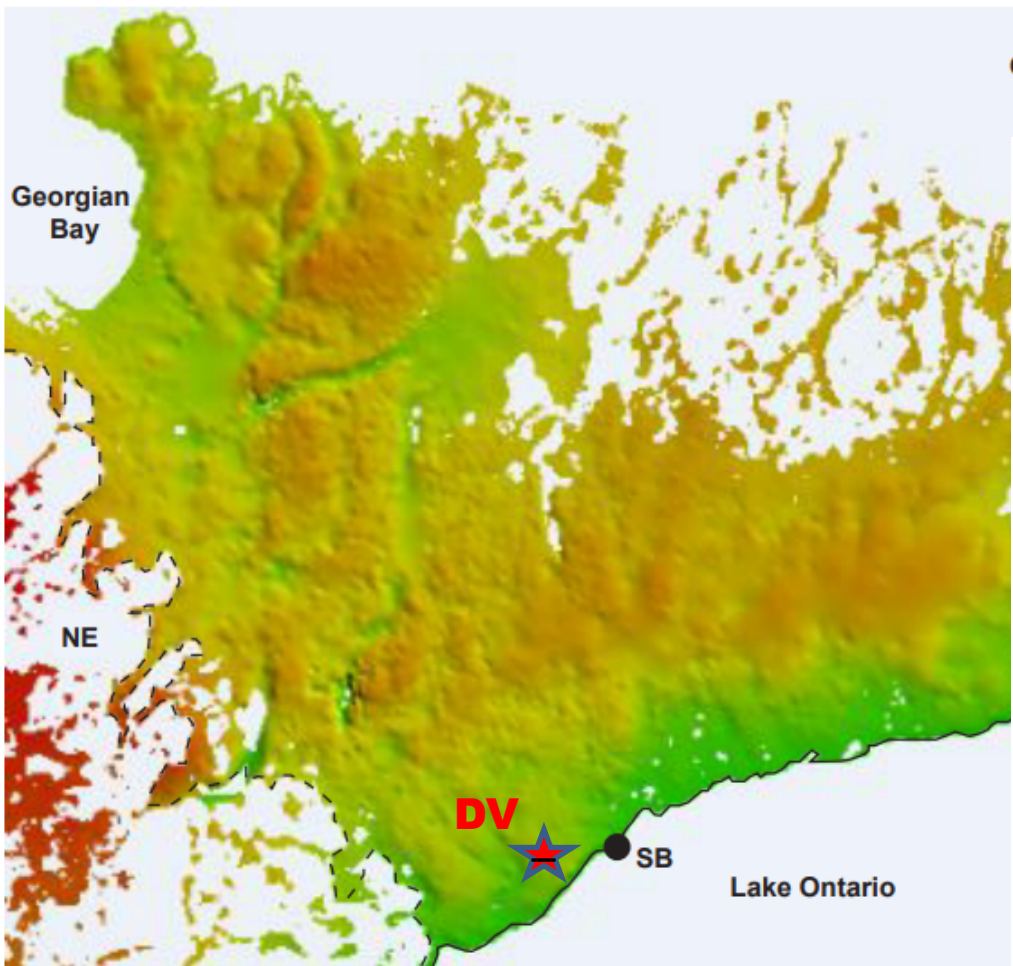Sharpe et al. 1997

ORM age channels

Brennand et al. 2006

Thorncliffe Formation –what is observed record?
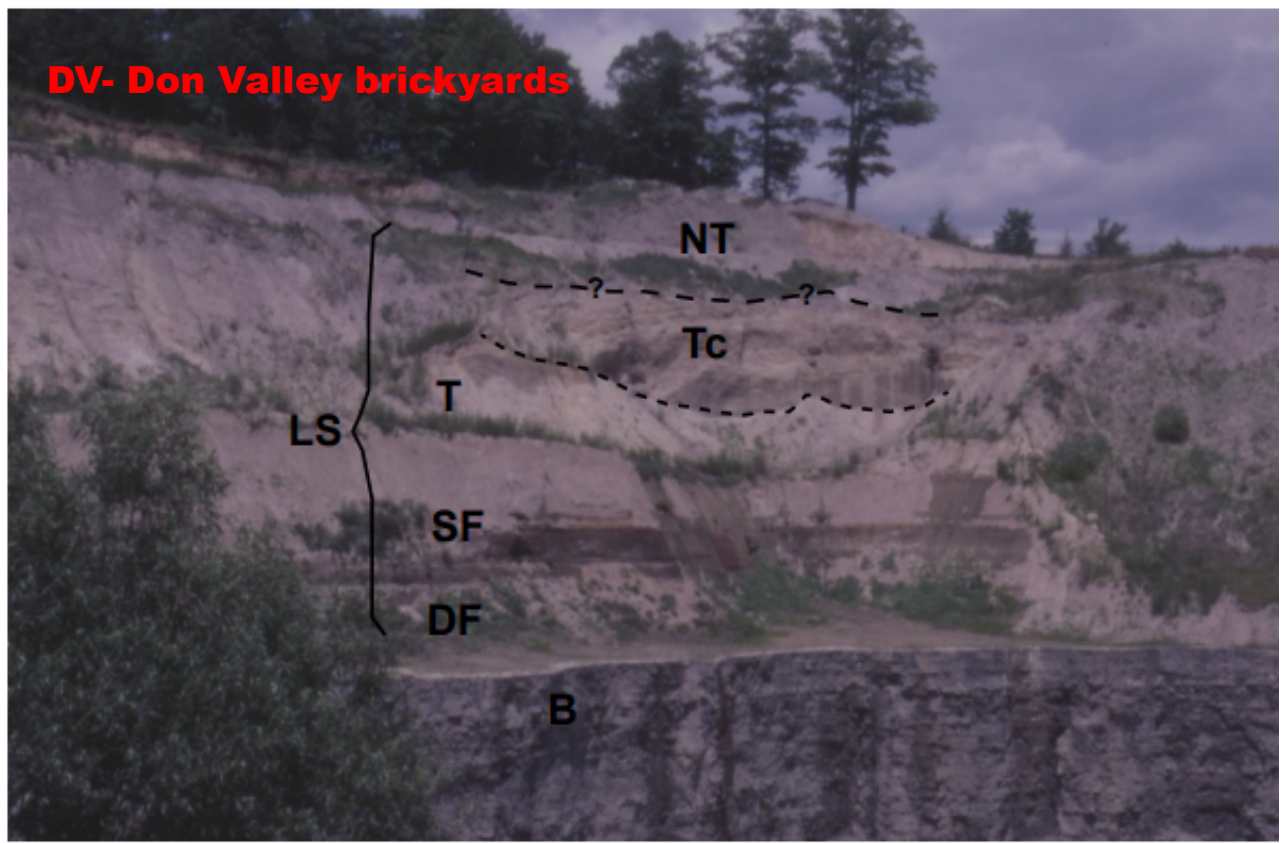
Lower sediment isopach map (< NT)

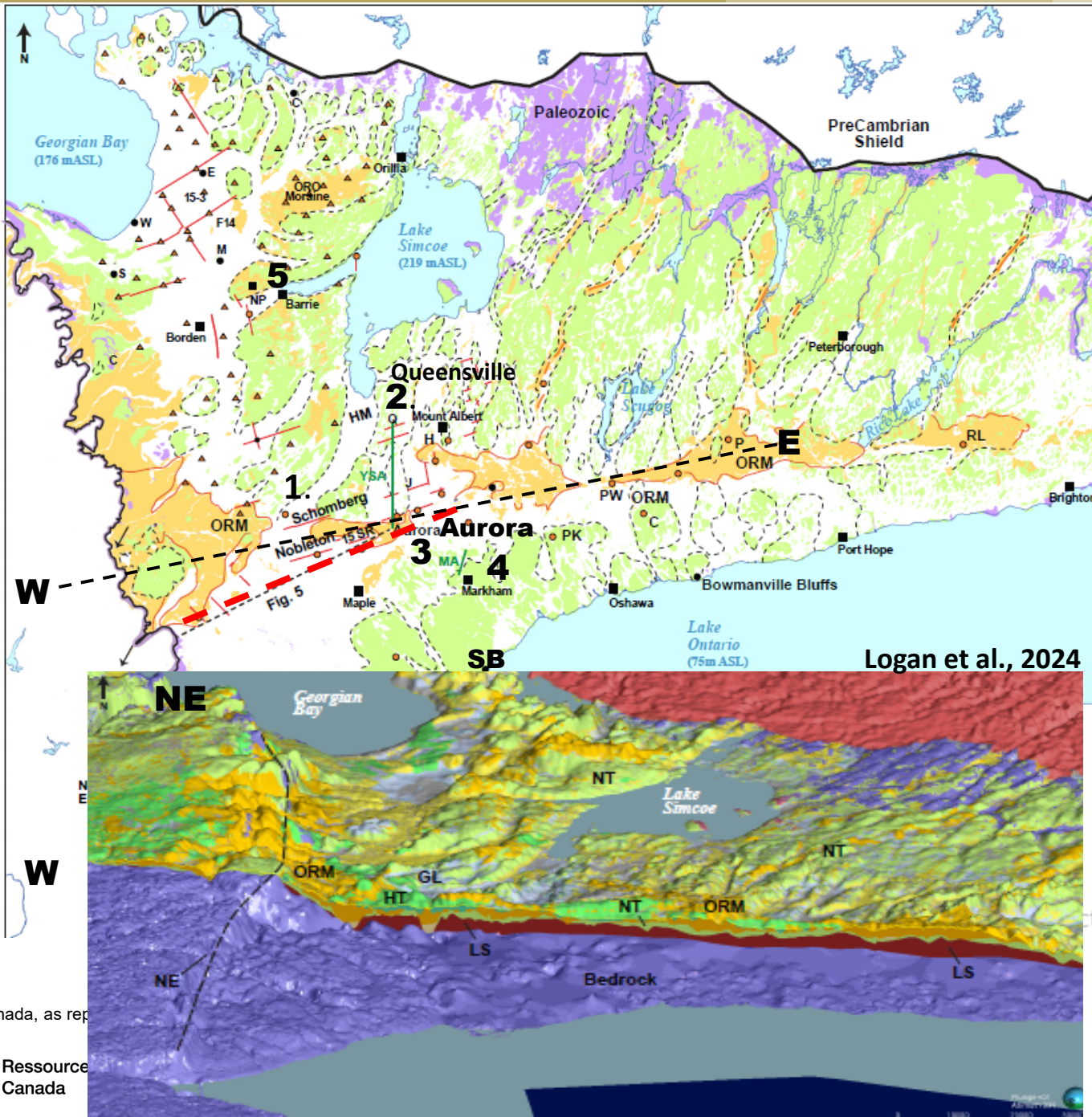Natural Resources Canada   Ressources naturelles Canada

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Thorncliffe Formation sediment thickness
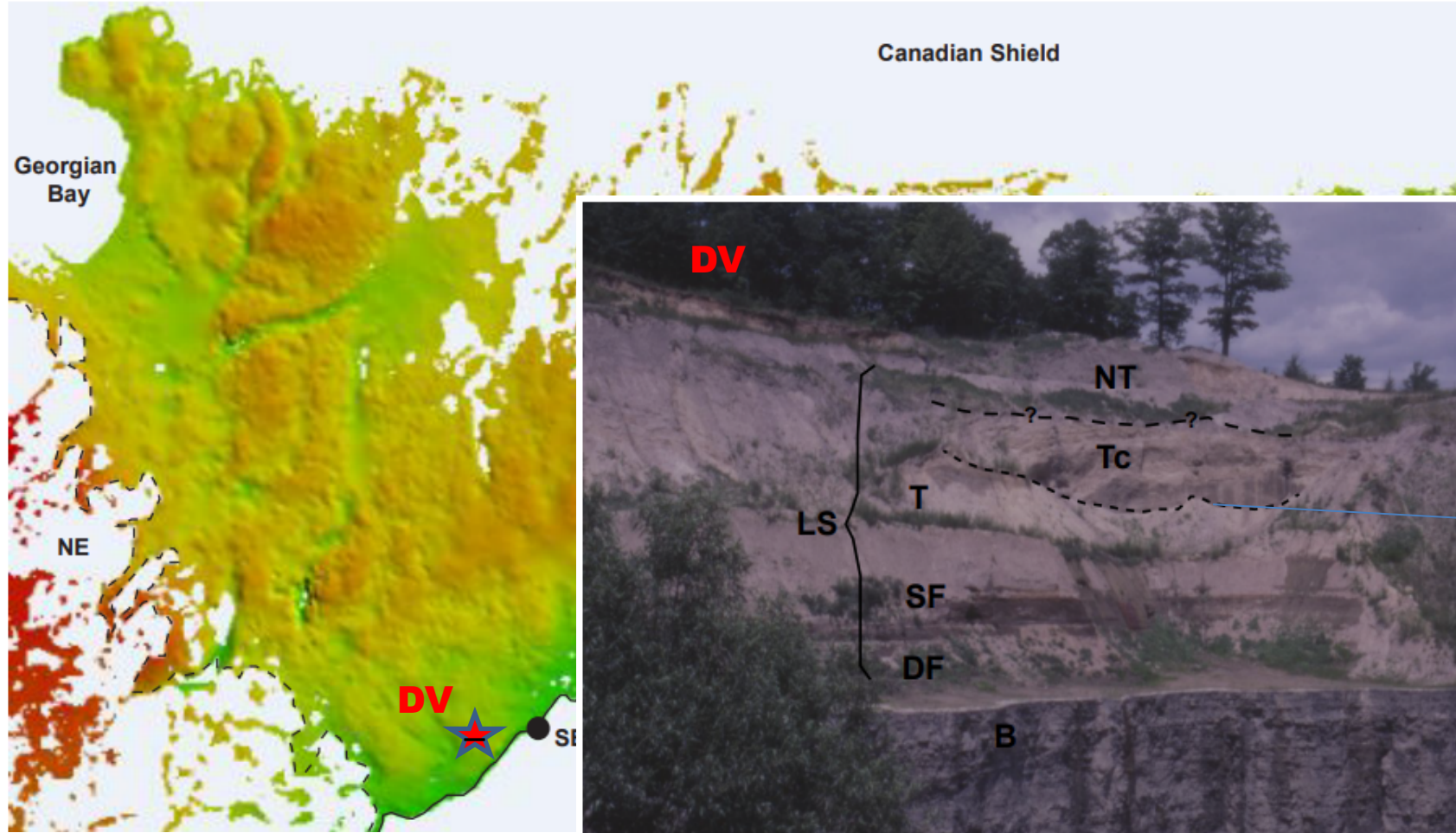
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High-Quality data sites

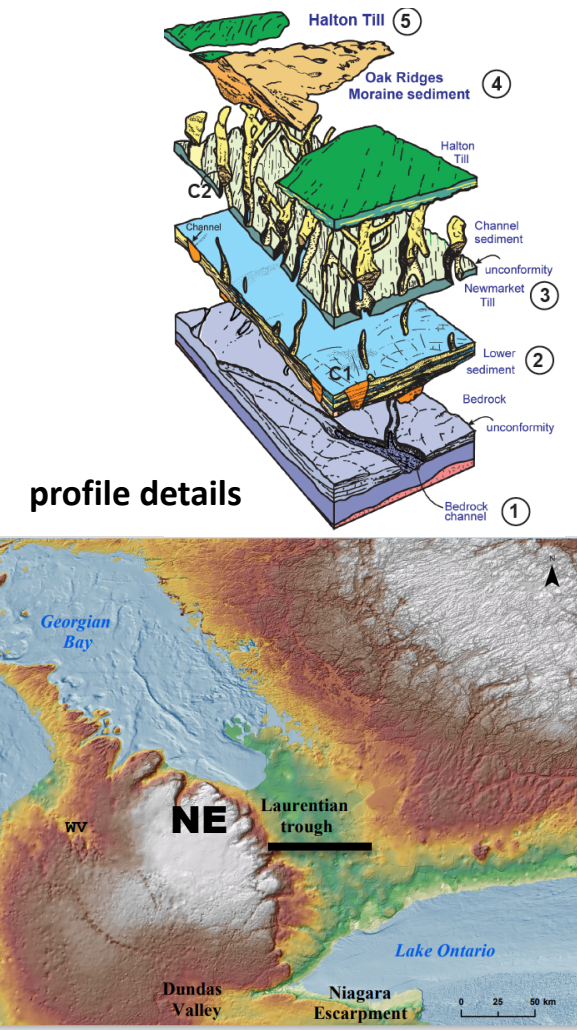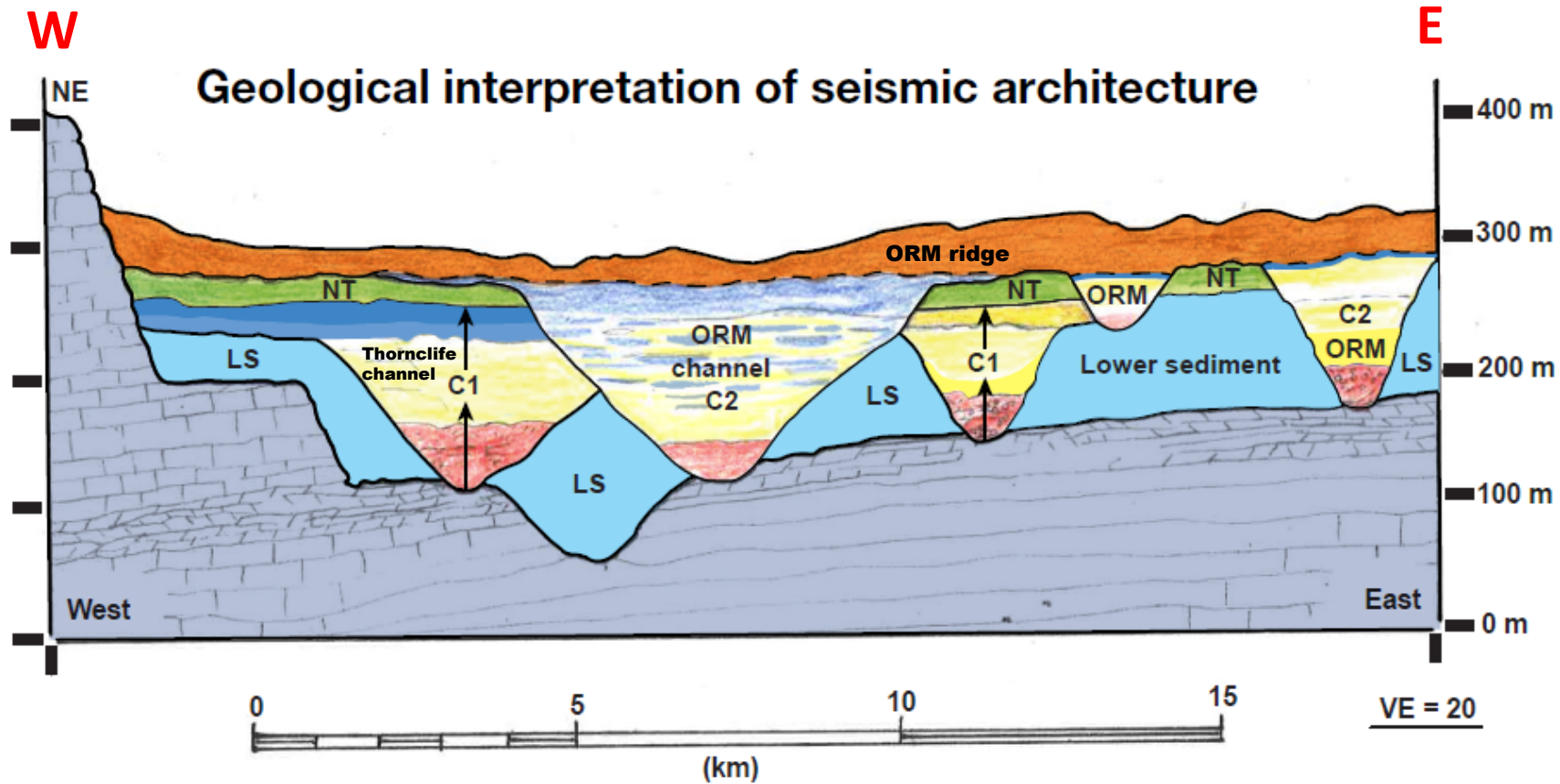Logan et al., 2024

Data sources
- geological mapping
- geological sections
- **seismic profiles**
- **continuous cores**
- core images
- hydraulic data

Schematic seismic summary

<u>3D model - perspective view</u>

WW = 147K
HQ coded = 10K (8K uncoded)

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Schematic X-section of seismic surveys across Laurentian trough

W   **E**

Geological interpretation of seismic architecture

profile details

Sharpe et al. 2018; 2023

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Schomberg seismic profile & continuous core
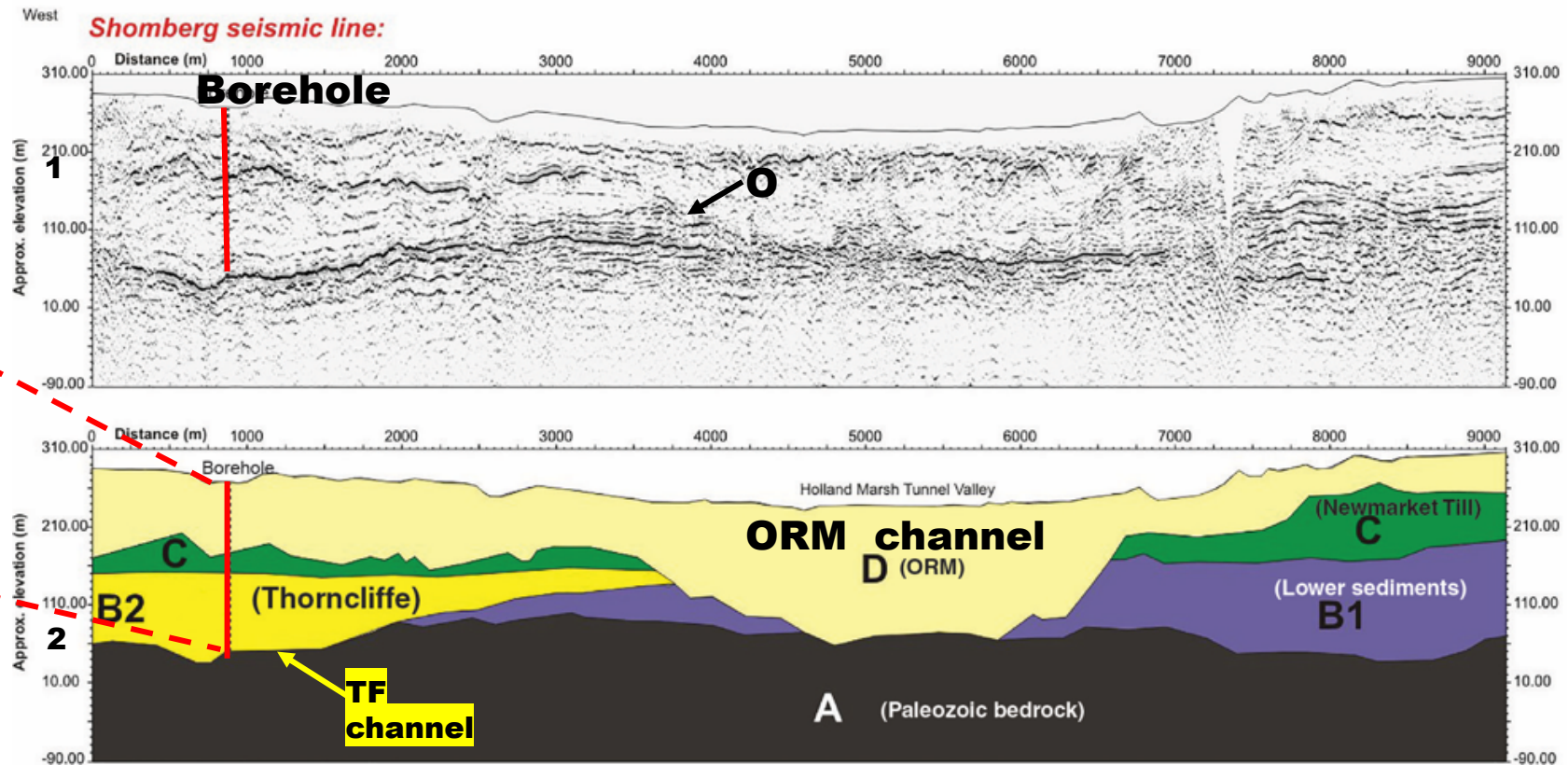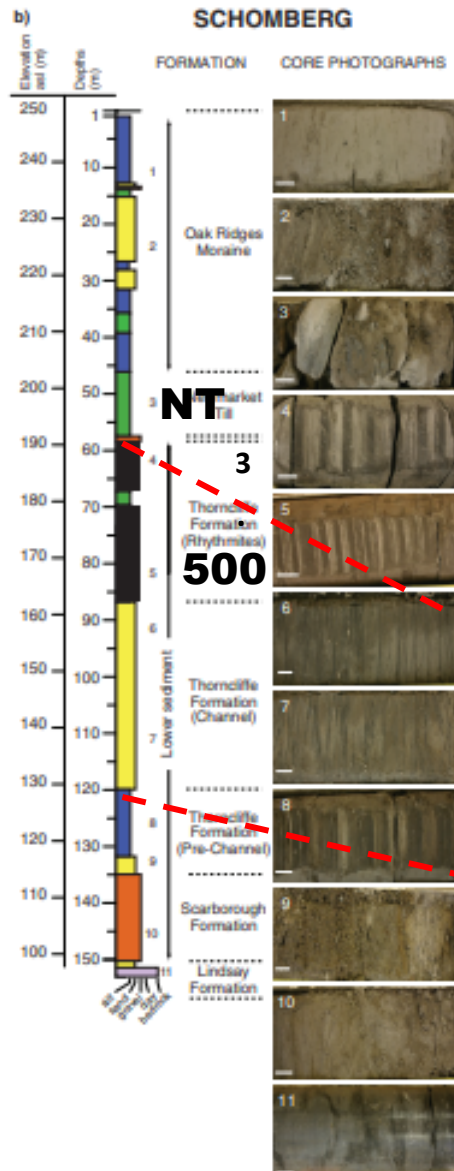
Sharpe et al. 2018

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Queensville seismic profile & continuous core

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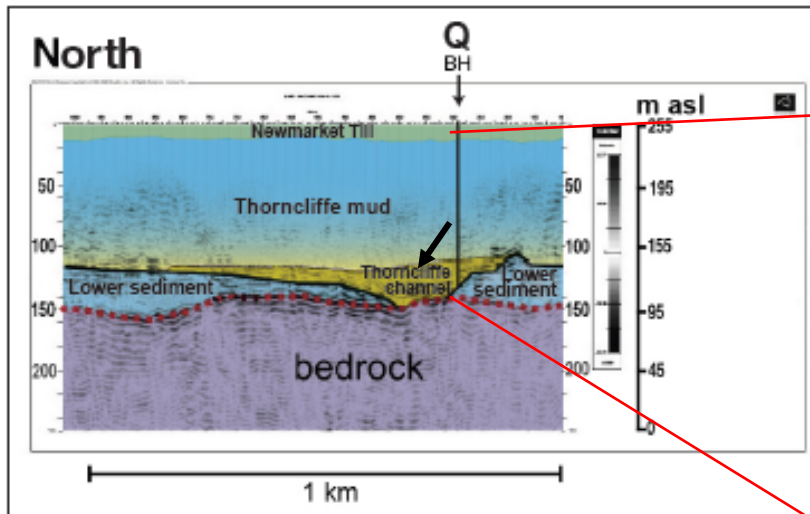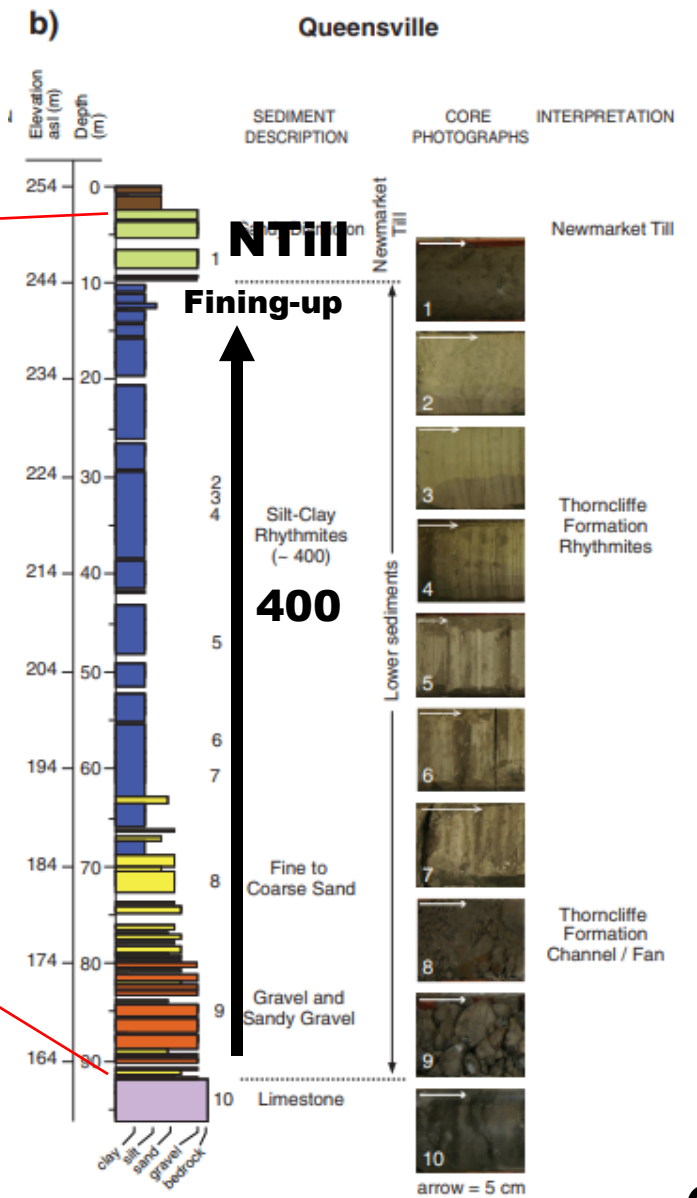Natural Re Canada
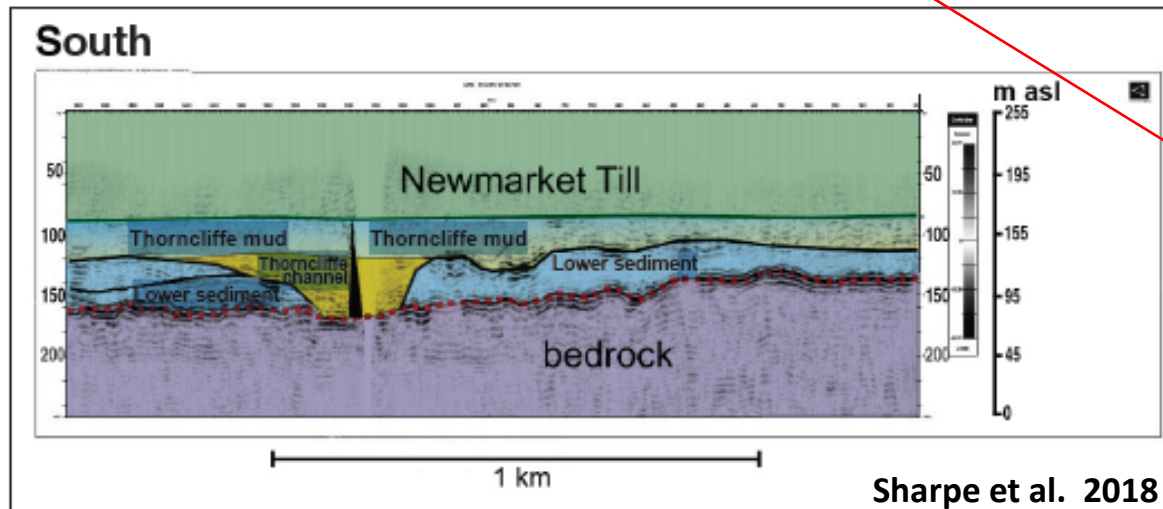
Sharpe et al. 2018

Aurora seismic profile & continuous core

NT eroded

Mud rhythmites

~400

3 debris flow

ORM channel

Sand

Gravel/ sand

Thorncliffe Fm fining-upward channel fill
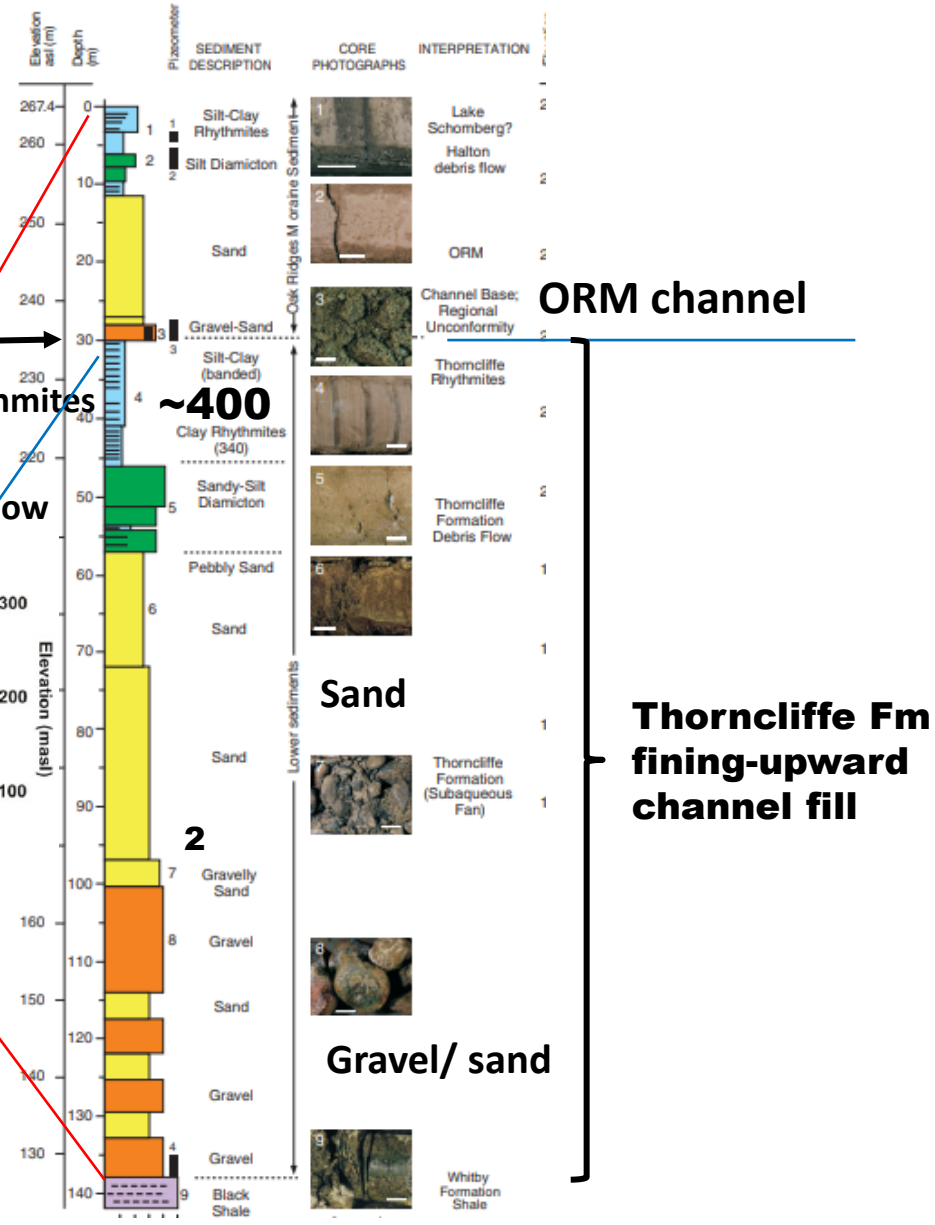
Sharpe et al. 2011; Gerber et al. 2018

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Queensville / Aurora in channel cores
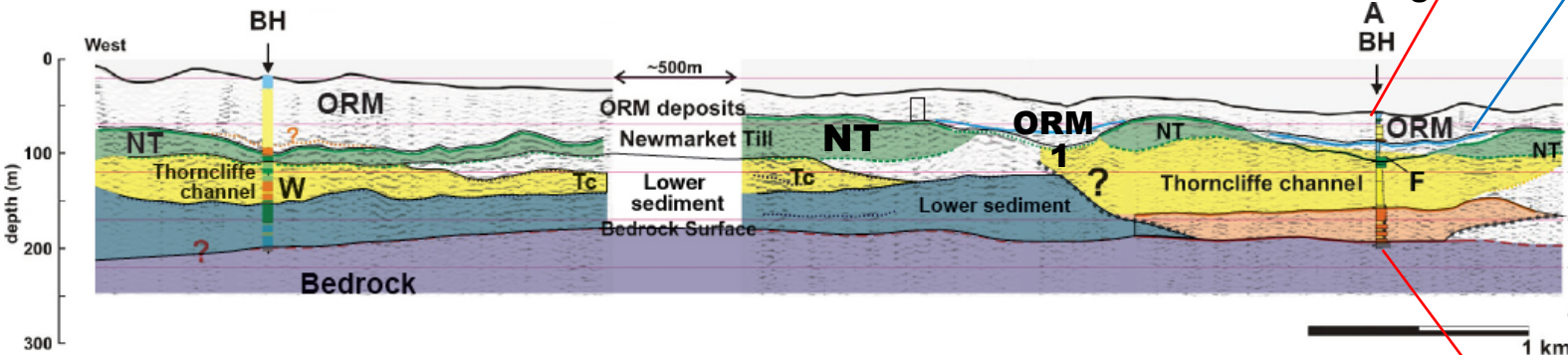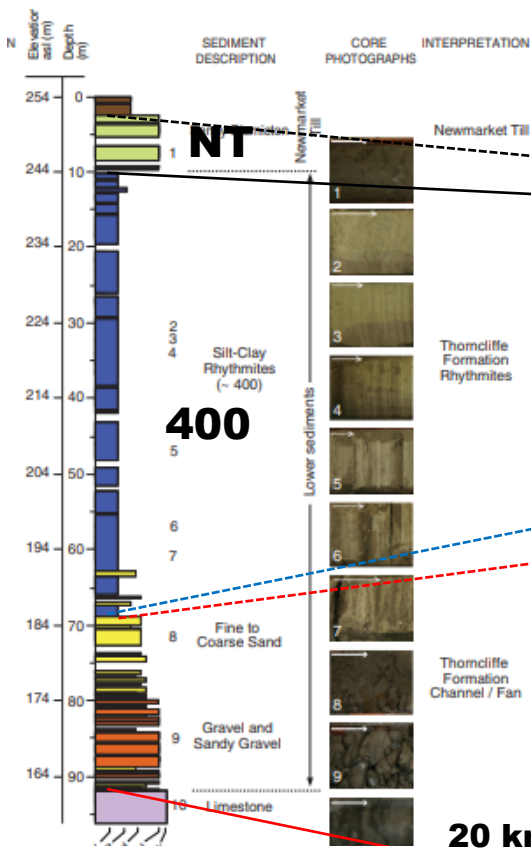

Thorncliffe Formation Rhythmites (~400)

Thorncliffe Formation Channel   (YS aquifer)

20 km section
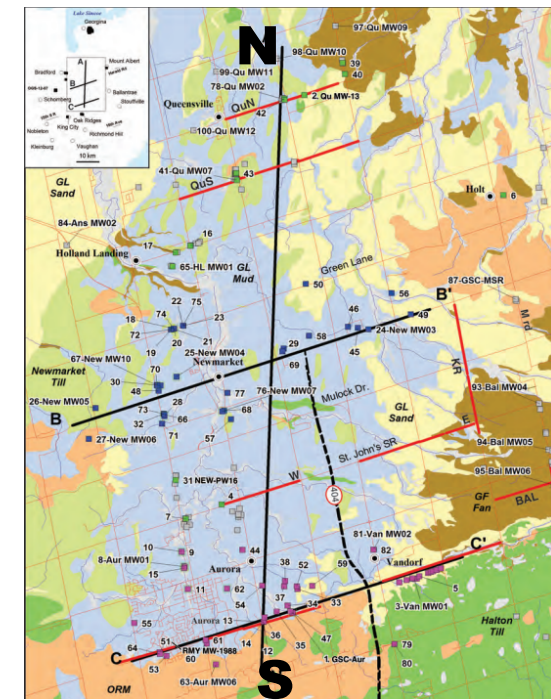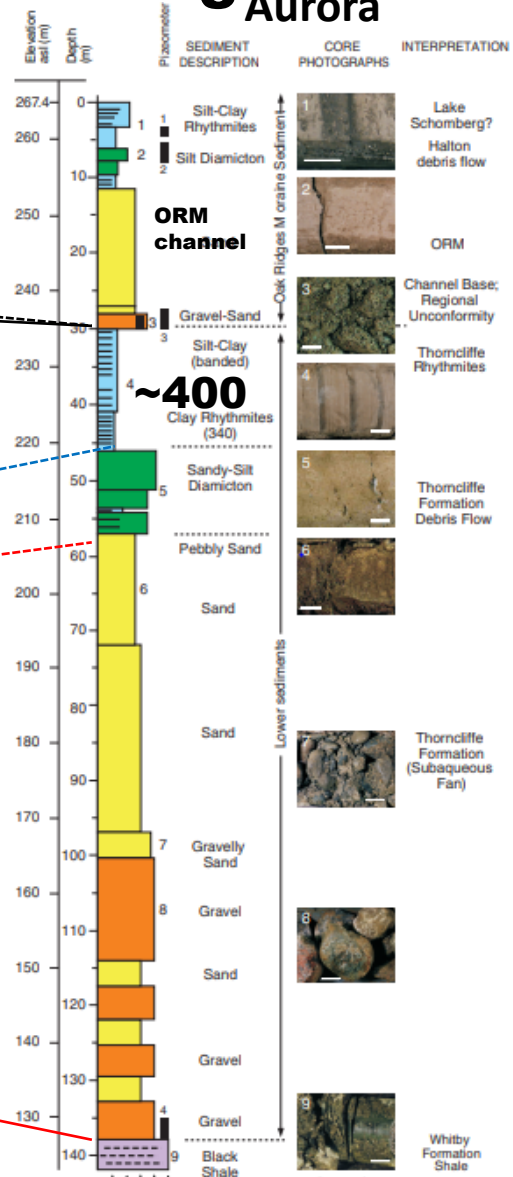
YS aquifer

N-S Queensville/ Aurora X-section:
Yonge Street Aquifer (YSA)

~20 km N-S section

Municipal pumping (>60 years):
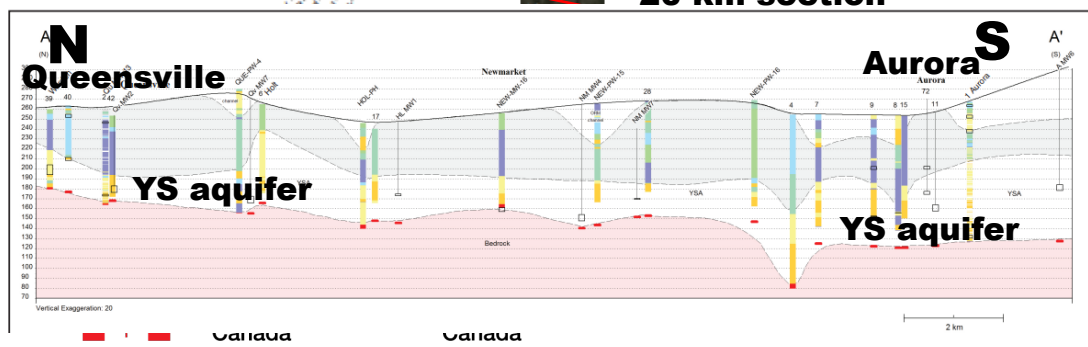- **20 km of strong NS hydraulic connection (2-3 km wide) confirms inferred channel-esker-fan system with ~N to S trend**
- *Markham channel aquifer (Sibul et al. 1977) & 16th ave issues (Sharpe et al. 2011)*

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Subaqueous Fan Depositional Model

Conceptual prospecting model   **Russell & Arnott 2003**

TF Fining upward sequence

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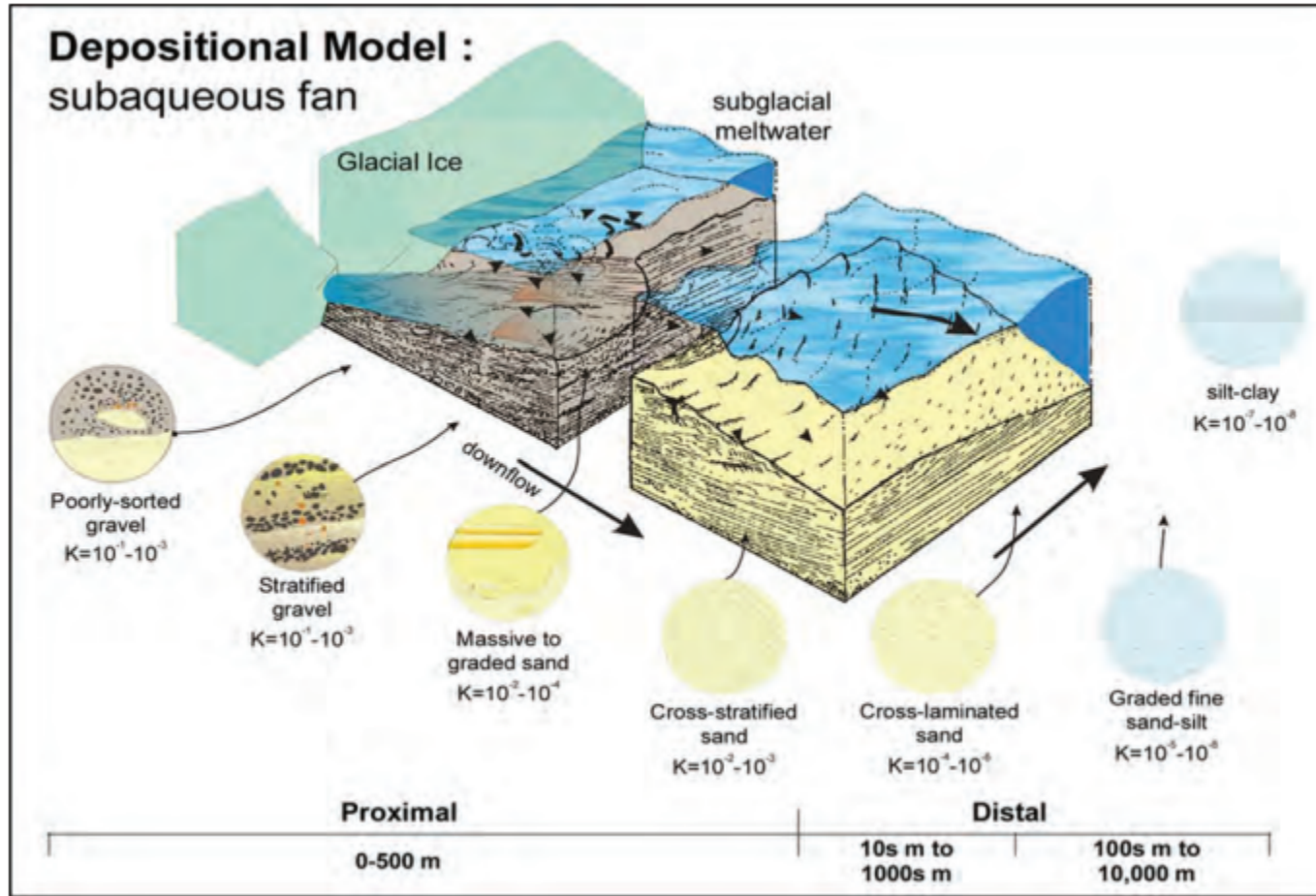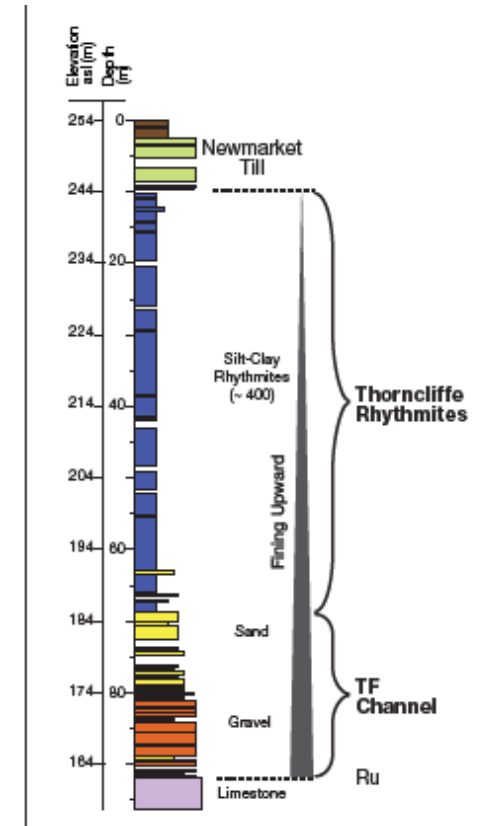
Thorncliffe Formation thickness map
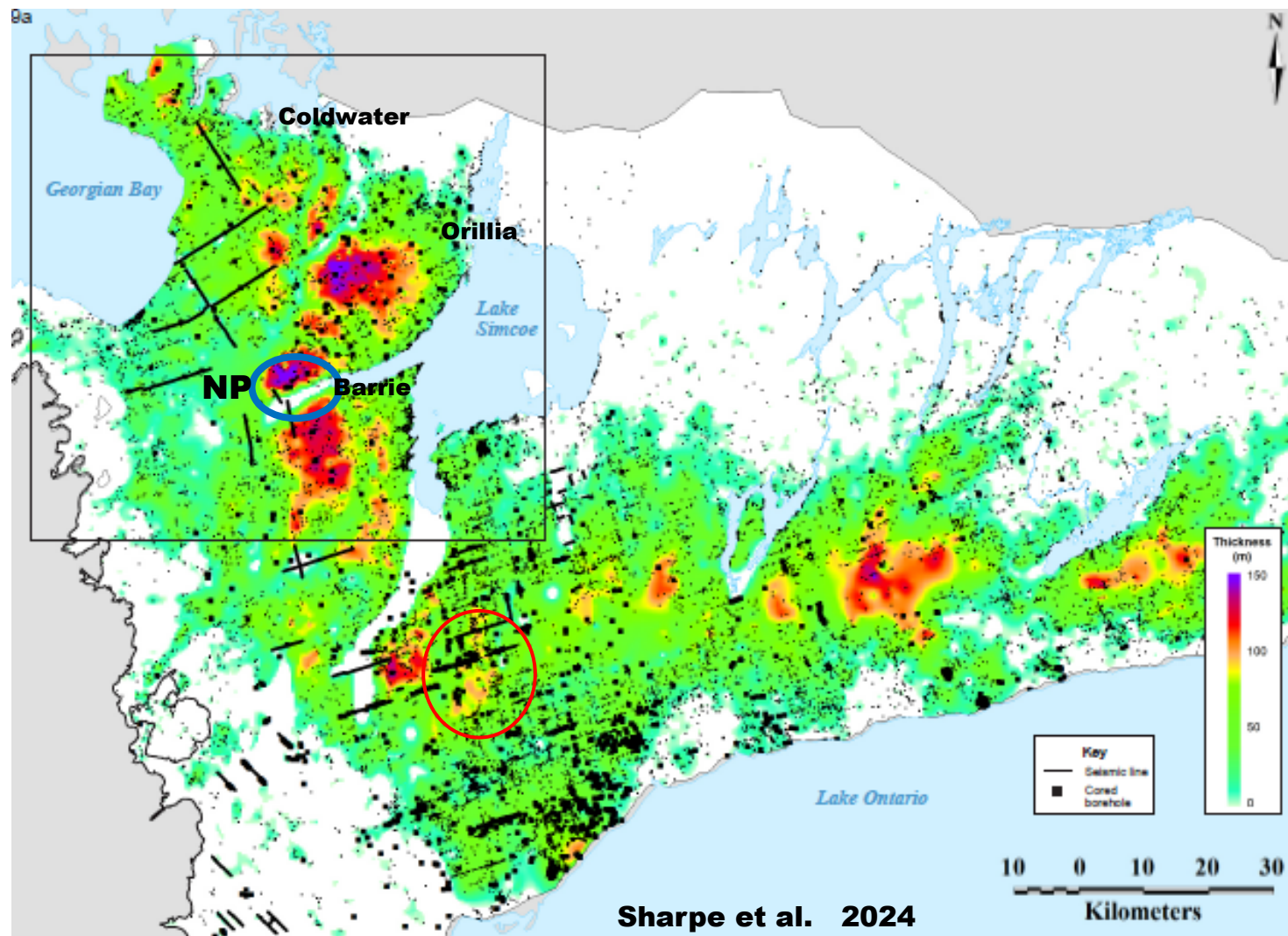
Sharpe et al.   2024

Modelled Thorncliffe sediment thickness

308 HQ data points ~10,000 ww records

TF> 100 m thick

1. **Areas of high sedimentation**

2. **Elevation of high TF mud**

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Thorncliffe Formation outcrops

NT

Midland

Barrie

Aurora

ORM channel

Newmarket till uplands
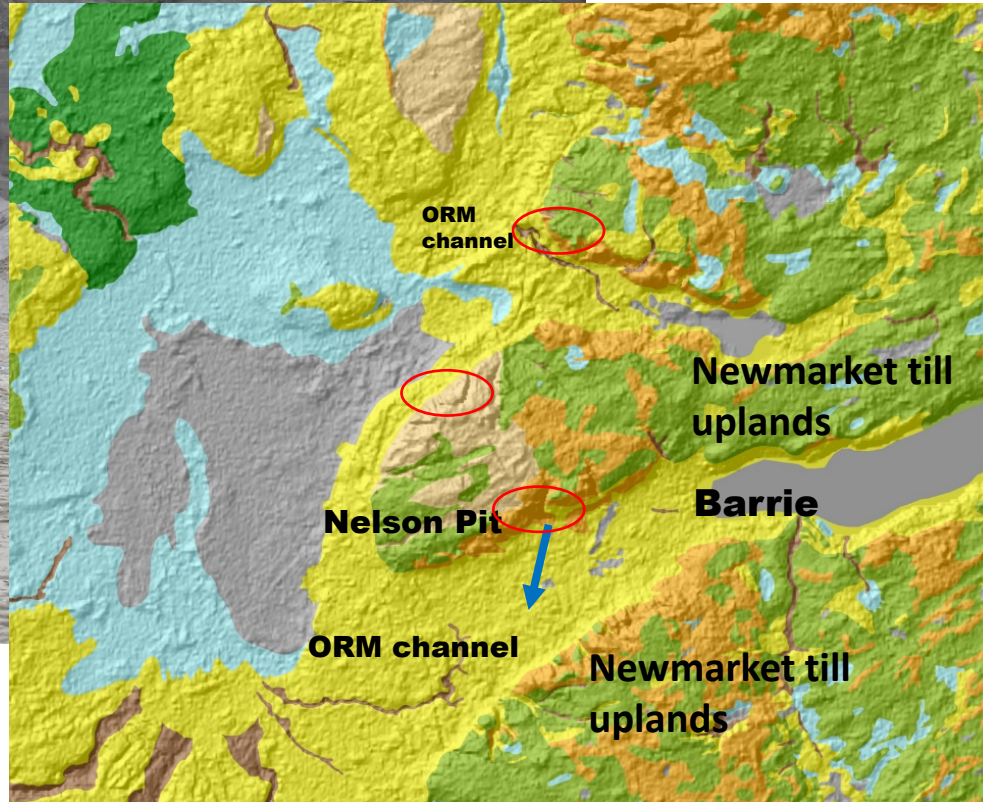
Nelson Pit

Barrie

ORM channel

Newmarket till uplands
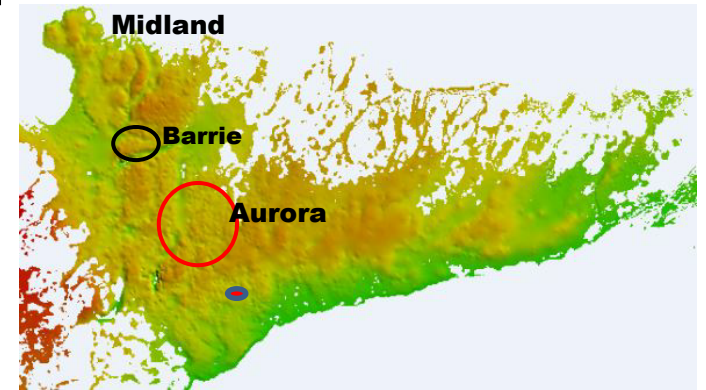
**Nelson Pit
West ot Barrie**

**Sharpe et al 2013
Slattery & Sharpe 2024**

~35 m of exposed sand/ gravel
~25 m borehole sand/ gravel

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Thorncliffe north of Barrie

Slattery & Sharpe 2024
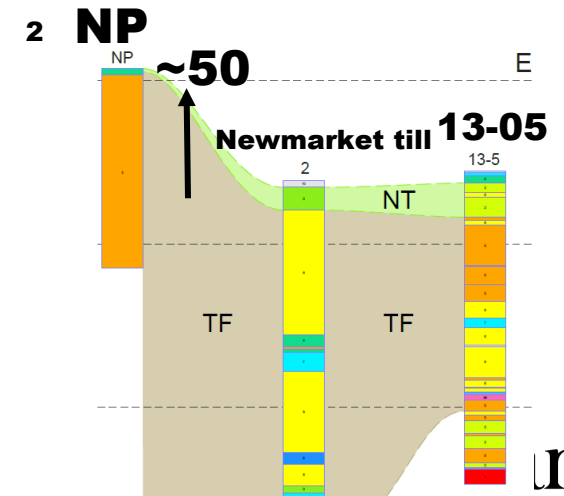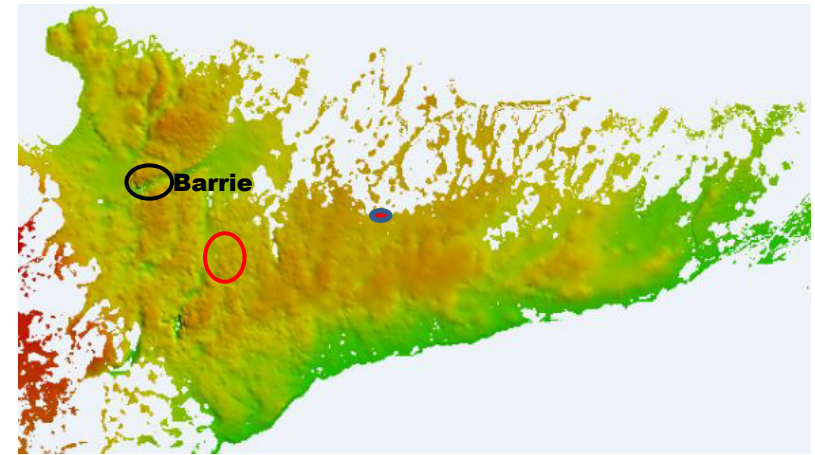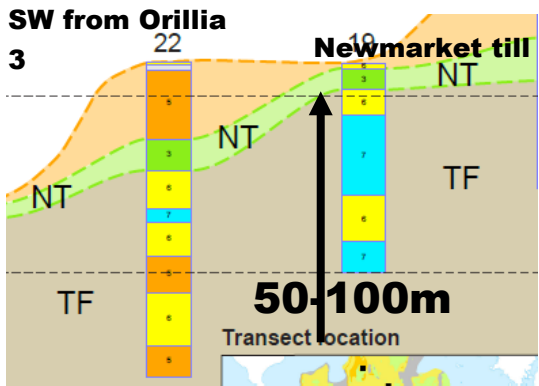
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Summary
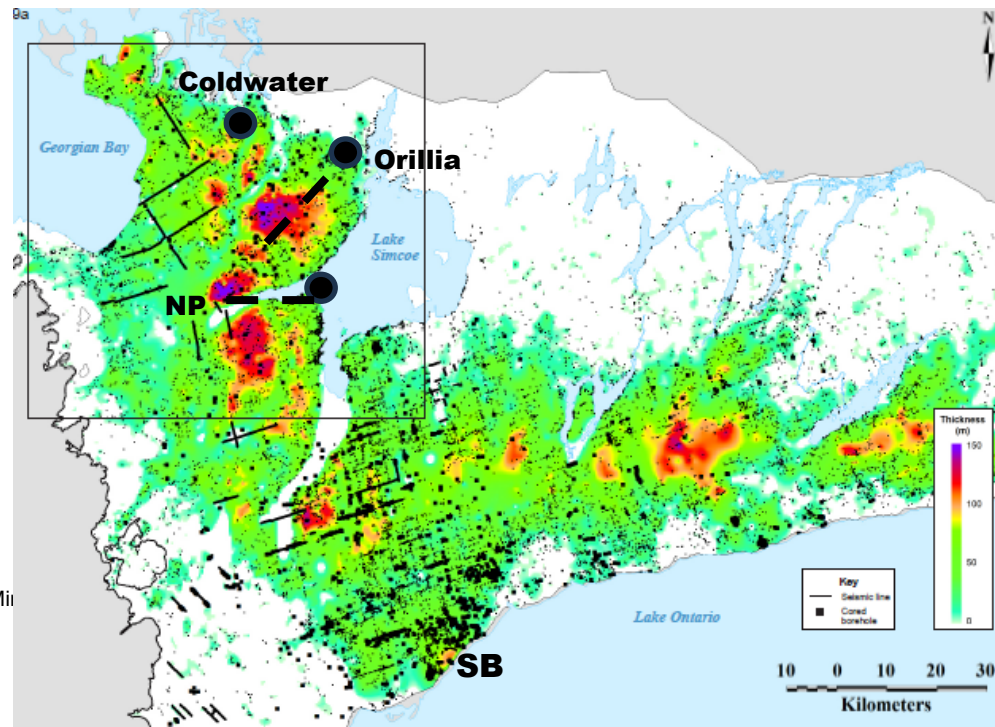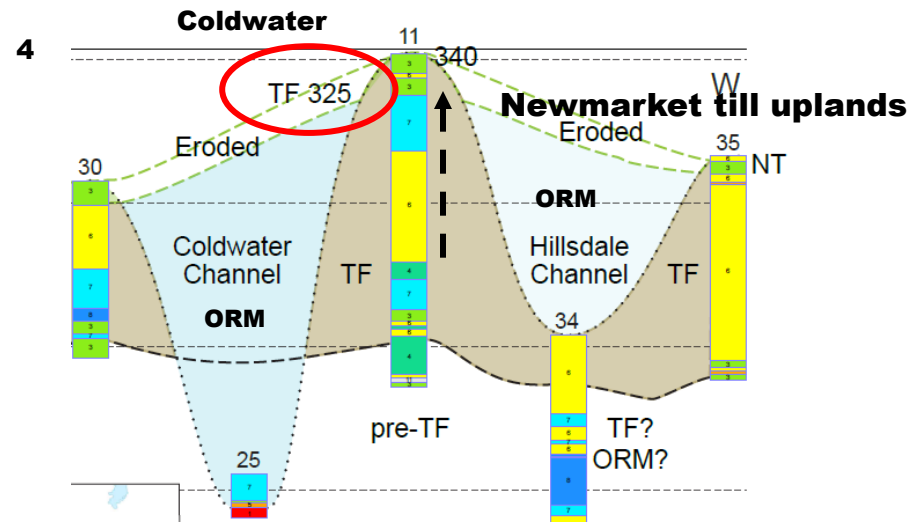# Thorncliffe Formation: large, thick glacial basin sequence

- TF: ~400 km³ of glacio-lacustrine basin sediment
- Mud with a network of channel-fan feeders (fan mounds)

- Channel-fan sediments show a diagnostic (gravel-sand-mud) fining upward sequence
- Two prolific, tested aquifer systems (Markham, YSA) inform the geological model

- Combined geological and hydrogeological data support a channel-fan depositional model
- Deltaic and fluctuating lake level models not supported by acquired high-quality data
- High-quality data (e.g., seismic, core) help ensure discovery of new productive (TF) aquifers

- The channel-fan prospecting model predicts the sedimentary nature of TF aquifers:
   architecture, facies character and trends, orientation, and geometry

Sharpe et al., 2024

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