Shale Gas Potential for the Ordovician Shale Succession of Southern Ontario*

Catherine Béland Otis[1]

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[1]Ontario Geological Survey, Sudbury, ON (catherine.belandotis@ontario.ca)

Abstract

In 2011, the Ontario Geological Survey (OGS) conducted a drilling program to assess shale gas potential for the Ordovician shale succession present in Southern Ontario. One well was cored to a depth of 496.5 m (~1,629 ft) and samples were collected and analyzed for gas desorption, adsorption isotherms, gas composition, methane gas isotopic composition, mineralogy, total organic content, Rock-Eval[6] pyrolysis, porosity, permeability, water and hydrocarbon saturations and rock mechanics. At this time, not all data has been received by the OGS. Also, the well was geophysically logged for gamma-ray, neutron, porosity, density, sonic and induction.

The Ordovician shale succession includes, in descending order, the Queenston, Georgian Bay and Blue Mountain formations, and the Collingwood Member of the Cobourg Formation. The Queenston Formation will not be considered here. The Georgian Bay Formation consists of about 89 meters (292 ft) of grayish to bluish shale and limestone. The Blue Mountain Formation consists of two parts: an upper 68 m (223 ft) thick unit characterized by blue-grey shales with some minor limestone beds; and a lower unit, called the Rouge River Member, which consists of 15 meters (49 ft) of organic-rich black shales. The contact of the Blue Mountain Formation with the underlying Collingwood Member is characterized by a phosphatic bed a few centimeters thick. The Collingwood Member consists of 8 meters (26 ft) of dark grey to black organic-rich calcareous lime mudstone.

The Georgian Bay and upper Blue Mountain formations, with organic content less than 1 wt%, have the highest porosity values (7.66 %), probably associated with limestone beds, whereas gas desorption values do not exceed 8.6 scf/ton. However, the Rouge River and Collingwood members, characterized by high total organic content (≤ 4.55 wt %) have the greatest gas desorption values (>15 scf/ton). Furthermore, oil saturation within the Rouge River Member reaches 31.5%, while the

Collingwood gas saturation is 77.2%. Gas composition is characterized by concentrations of methane from 83.6% to 94.6 %, of ethane from 3.7% to 7.9% and of propane and heavier hydrocarbons from 1.5% to 5.8%. Methane isotopic composition includes $\delta^{13}C_{C1}$ values ranging from -38.9‰ to -25.7‰ and δD_{C1} values from -213.5‰ to -188.0‰.

Future work by the OGS includes a regional study of the Ordovician shale succession to evaluate the units' extent and to establish their stratigraphic equivalents in adjacent jurisdictions, if any. Geology, organic content, Rock-Eval[6] pyrolysis and mineralogy profiles will be produced for about 12 wells located throughout Southern Ontario.

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By Catherine Béland Otis

Ontario Geological Survey

AAPG Eastern Meeting

Sept 25th 2012, Cleveland, Ohio

ONTARIO GEOLOGICAL SURVEY

Ontario

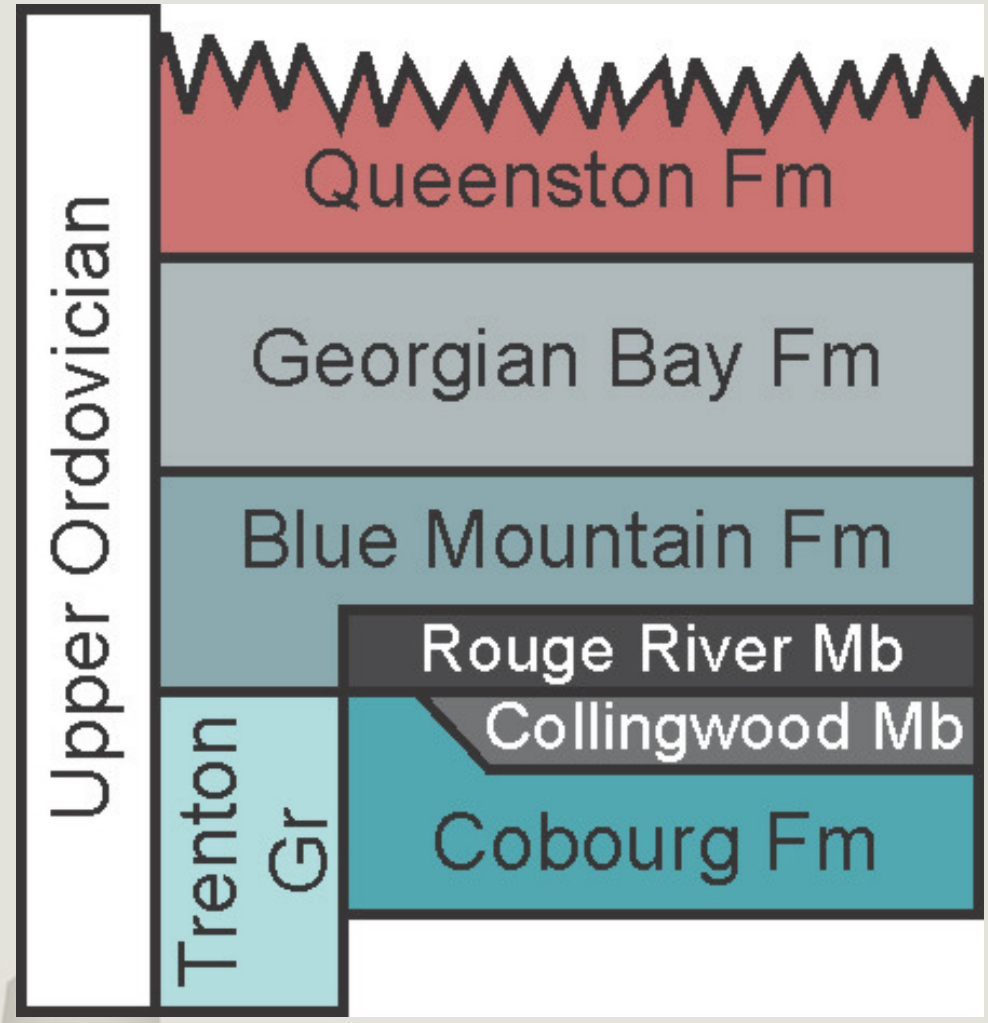
Plan

- History to the project
- Ordovician shale stratigraphy
- Drilling/sampling program (2011)
- Sampling program (2012)
- Conclusions

Introduction

- 2009:
  - Start of project (May)
  - Literature review
  - Planning for drilling
- 2010:
  - Drilling/sampling of 2 wells
    - Kettle Point Formation
      - Devonian
      - Shallow
      - Biogenic ± thermogenic
- 2011:
  - Drilling/sampling of 1 well
    - Ordovician shales
- 2012:
  - Sampling of previously drilled wells
    - Rock-Eval^{6} pyrolysis
    - XRD

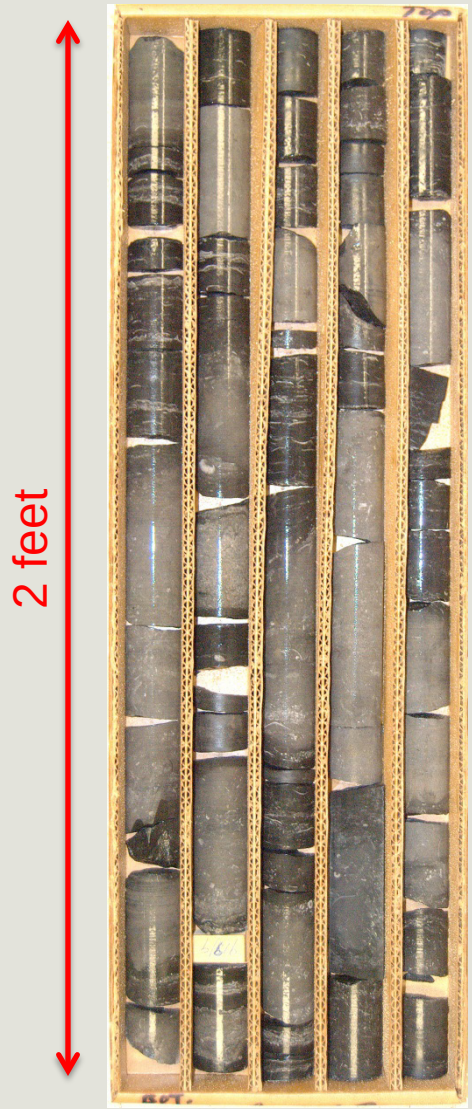
Ordovician shales



- Queenston Fm
  - Not studied
- **Georgian Bay Fm**
- **Blue Mountain Fm**
  - **Rouge River Mb**
- Cobourg Fm
  - **Collingwood Fm**

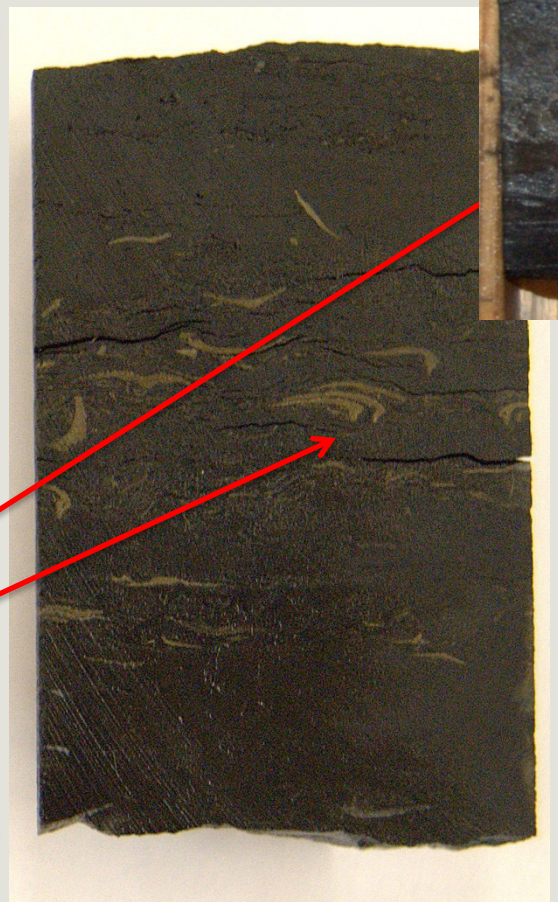
Collingwood Mb of the Cobourg Fm

- Lithology:
  - Calcareous shale or mudstone
  - High TOC (≤ 8 wt%)
  - Thickness:
    - Average: 6m
    - Max: 10m
- Other:
  - Oil source for Cambro-Ordovician reservoirs
  - Possible presence of cap-dolomite



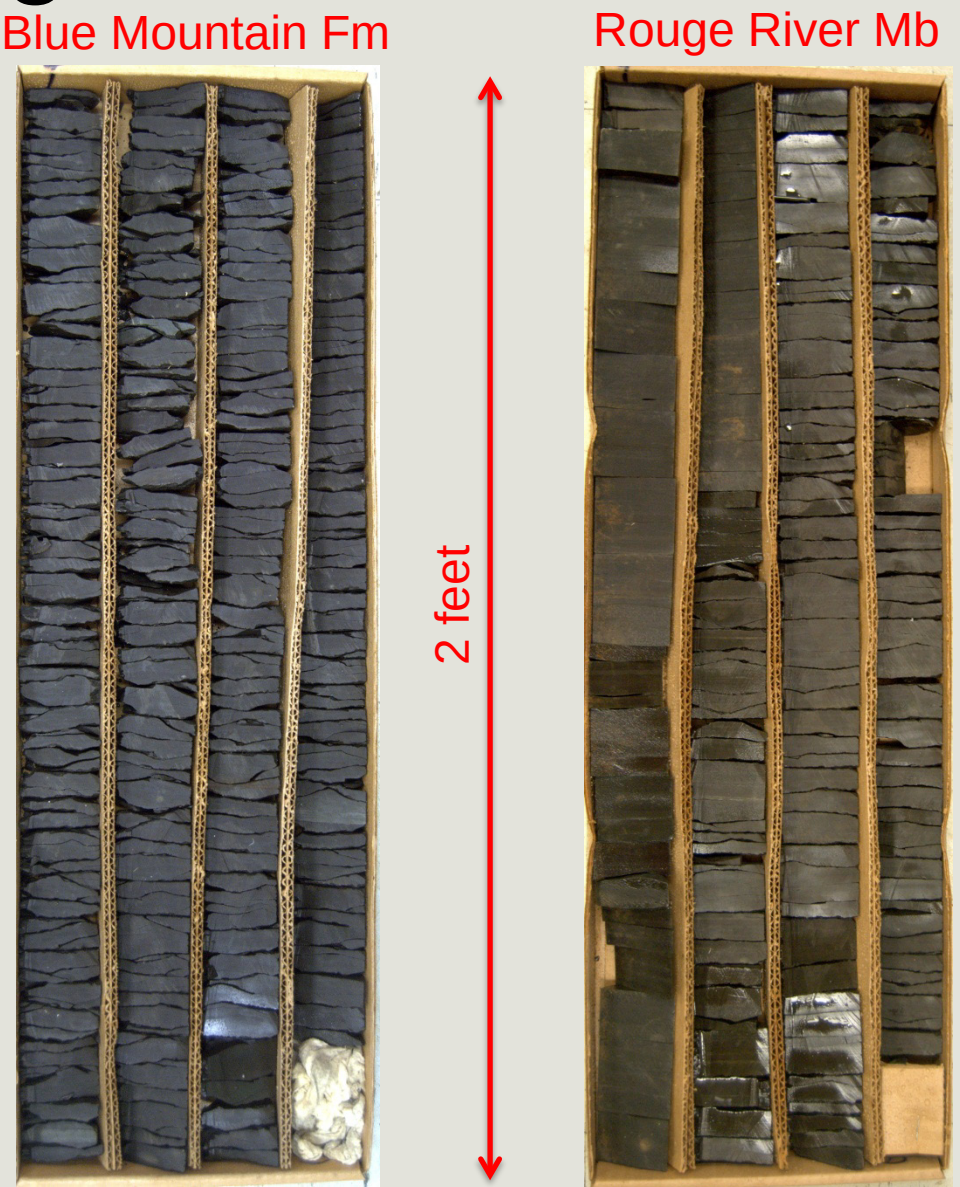
Collingwood Mb of the Cobourg Fm

- Contacts:
  - Lower
    - Cobourg / Collingwood
      - Transitional
      - 1st 10cm shale/ mudstone bed
  - Upper
    - Collingwood Mb/ Blue Mountain Fm (Rouge River)
    - Sharp
      - Phosphate
      - Pyrite



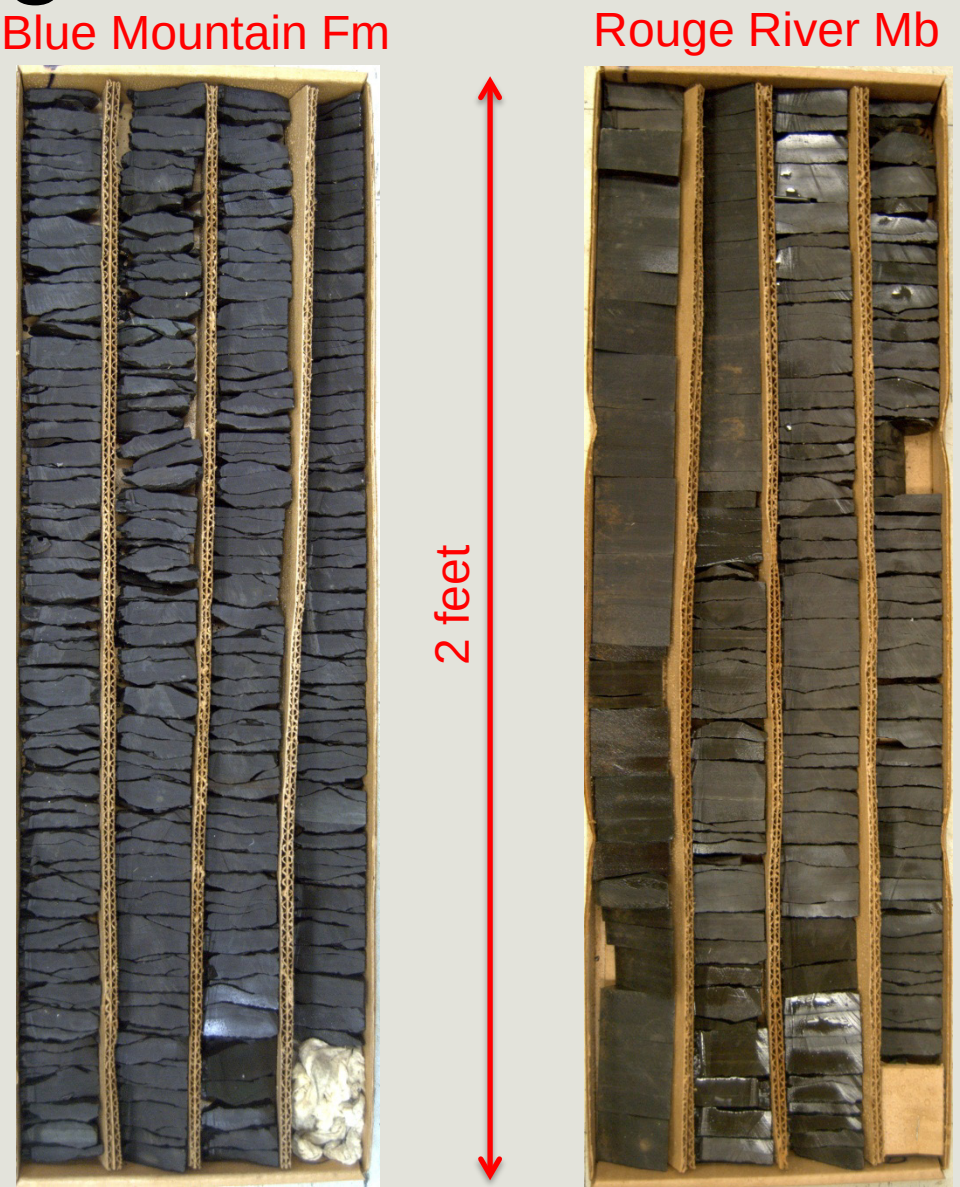
Blue Mountain Fm and the Rouge River Mb

- Lithology:
  - Rr Mb: Dark brown to black shale
  - BM Fm: Blue grey to brown shale and siltstone
  - Fissile
  - Medium TOC
    - 0.2 – 2.7 wt%
  - Thickness
    - Rr Mb:
      - Average: 15m
      - Maximum: 37 m
    - BM Fm: ≤ 100 m
      - Ottawa region



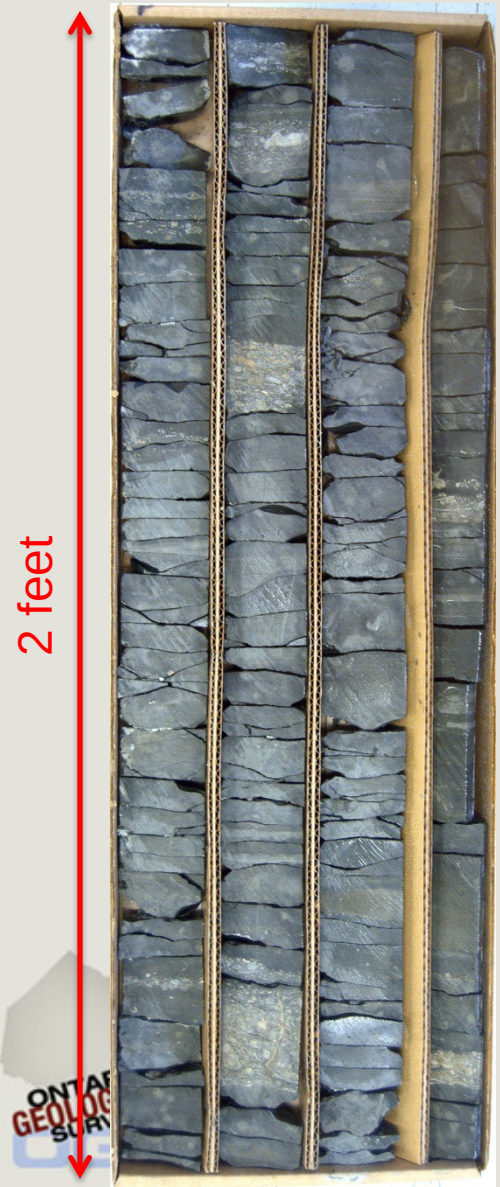
Blue Mountain Fm and the Rouge River Mb

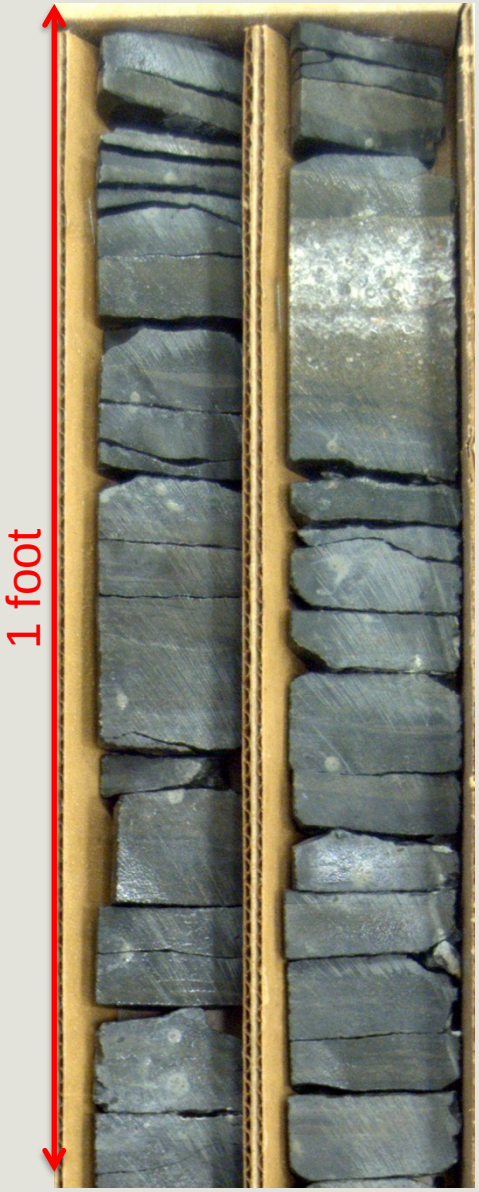
- Contacts
  - Rouge River Mb/ Blue Mountain Fm:
    - Transitional
    - 1st 1 cm bluish bed
  - Blue Mountain Fm/ Georgian Bay Fm:
    - Transitional
    - 1st 1 cm fossil bed



ONTARIO GEOLOGICAL SURVEY OGS

Georgian Bay Fm





- Lithology:
  - Greenish to bluish shale
  - + siltstone, sandstone and limestone
  - Storm beds, erosion surfaces, fossils
  - Low TOC
    - 0.1 – 0.6 wt %
  - Thickness:
    - Average: 130 m
    - Maximum: 175 m

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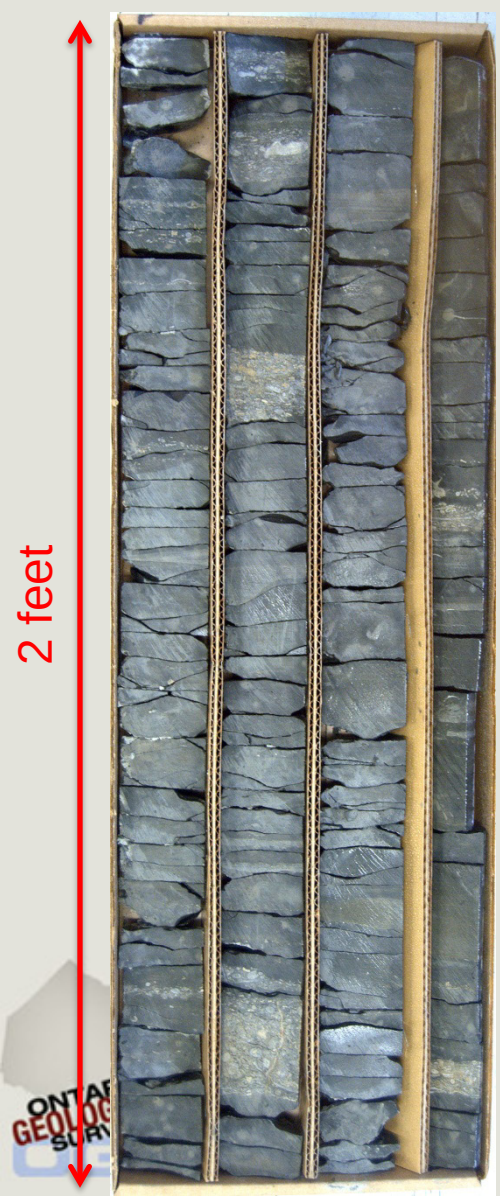
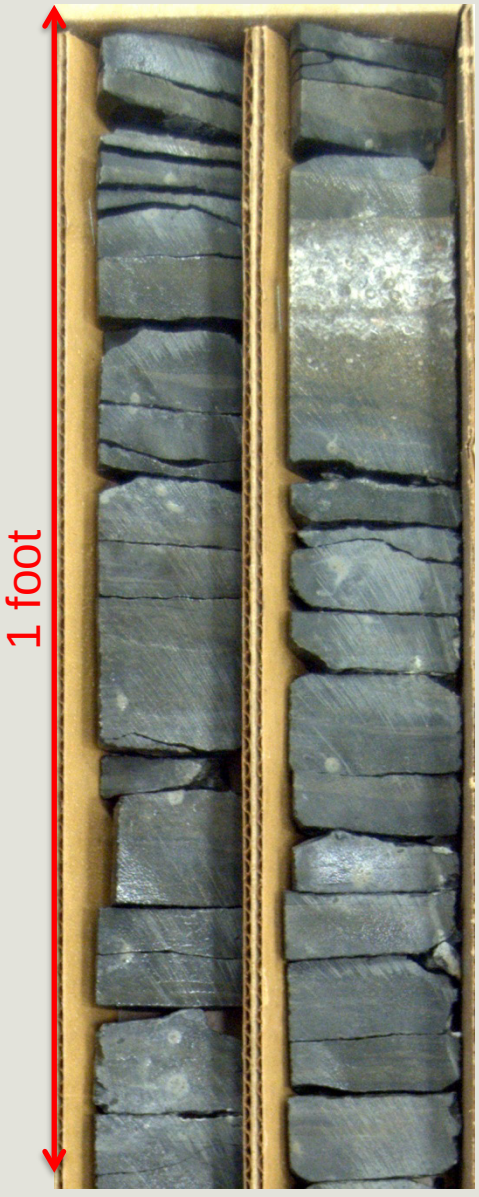
Georgian Bay Fm





- Contacts:
  - Upper: 1st appearance of red shales (Queenston Fm)

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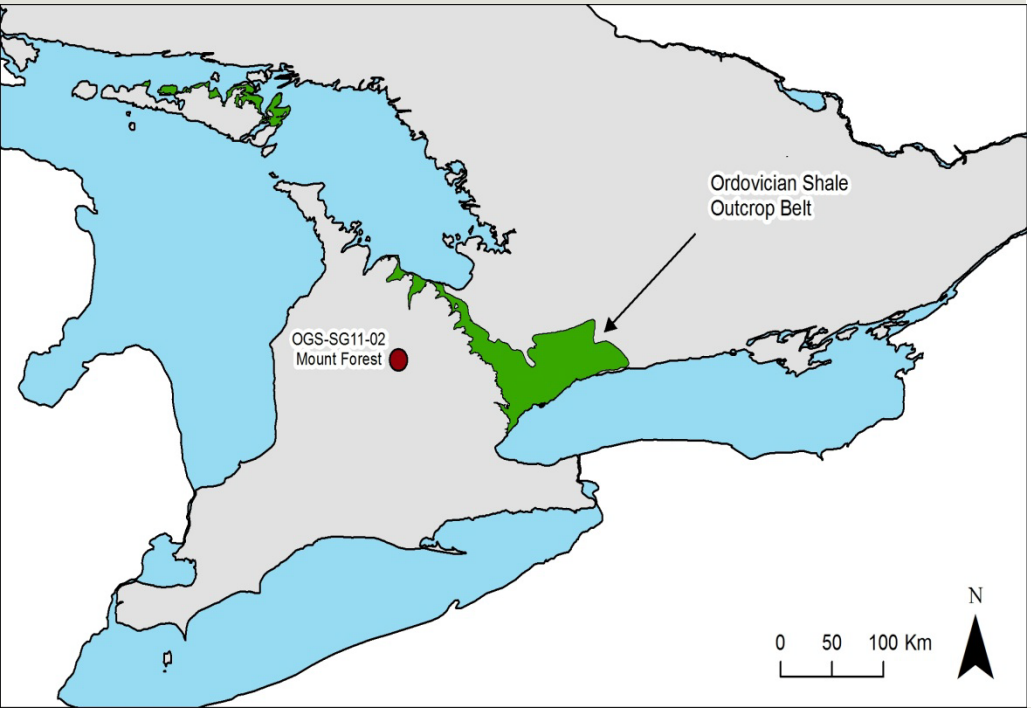
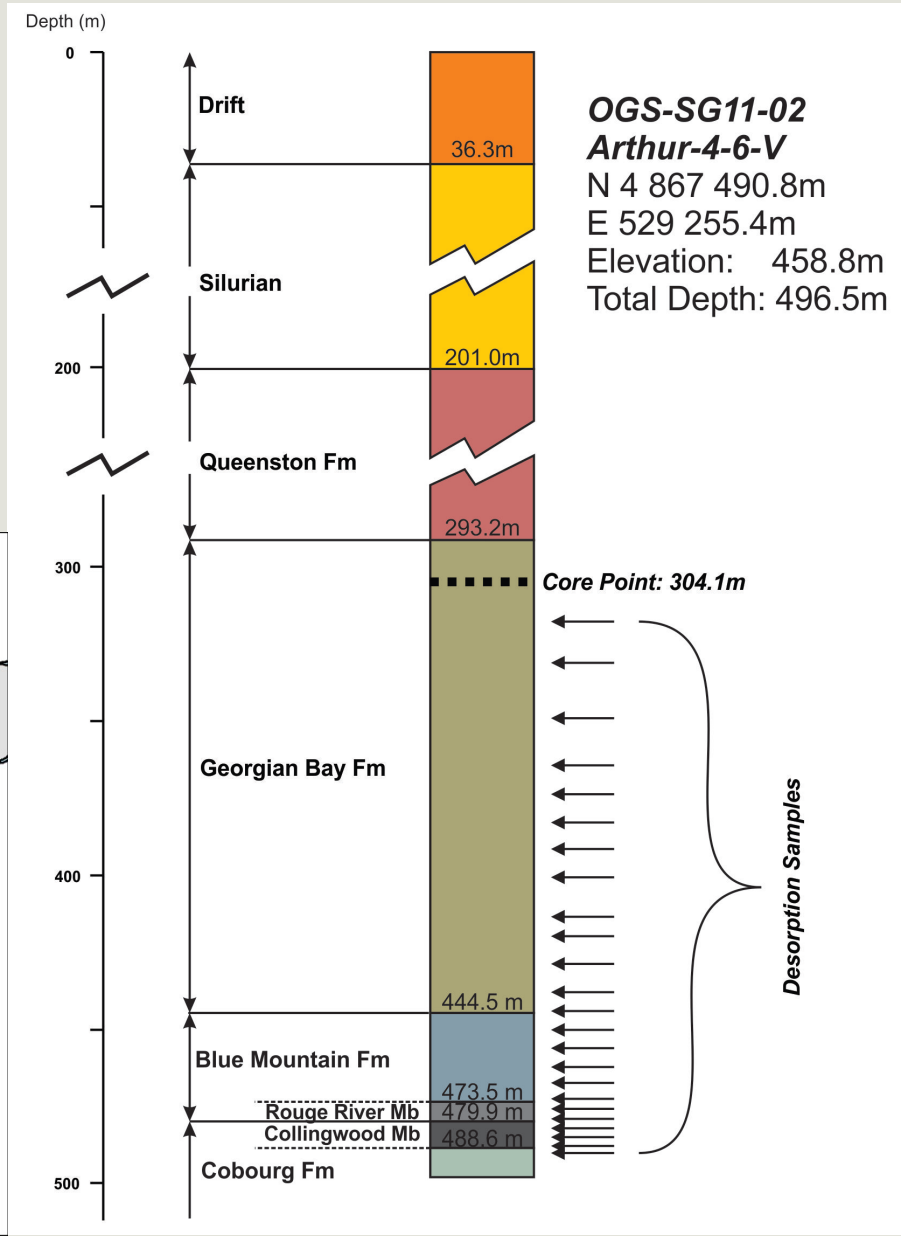
Drilling/Sampling (2011)

- Entire Ordovician shale succession
- Down to 500 meters
- Coring: > 300m deep
- Rock/gas samples
- Geophysics





Samples

- Samples
  - 24 gas samples
    - Desorption
    - Gas composition
    - Isotopes of methane
    - Adsorption isotherms
  - 5 GRI
    - Permeability
    - Porosity
    - Water/oil/gas saturation
  - 5 rock mechanics
  - 10 TOC
  - XRD+RE to come

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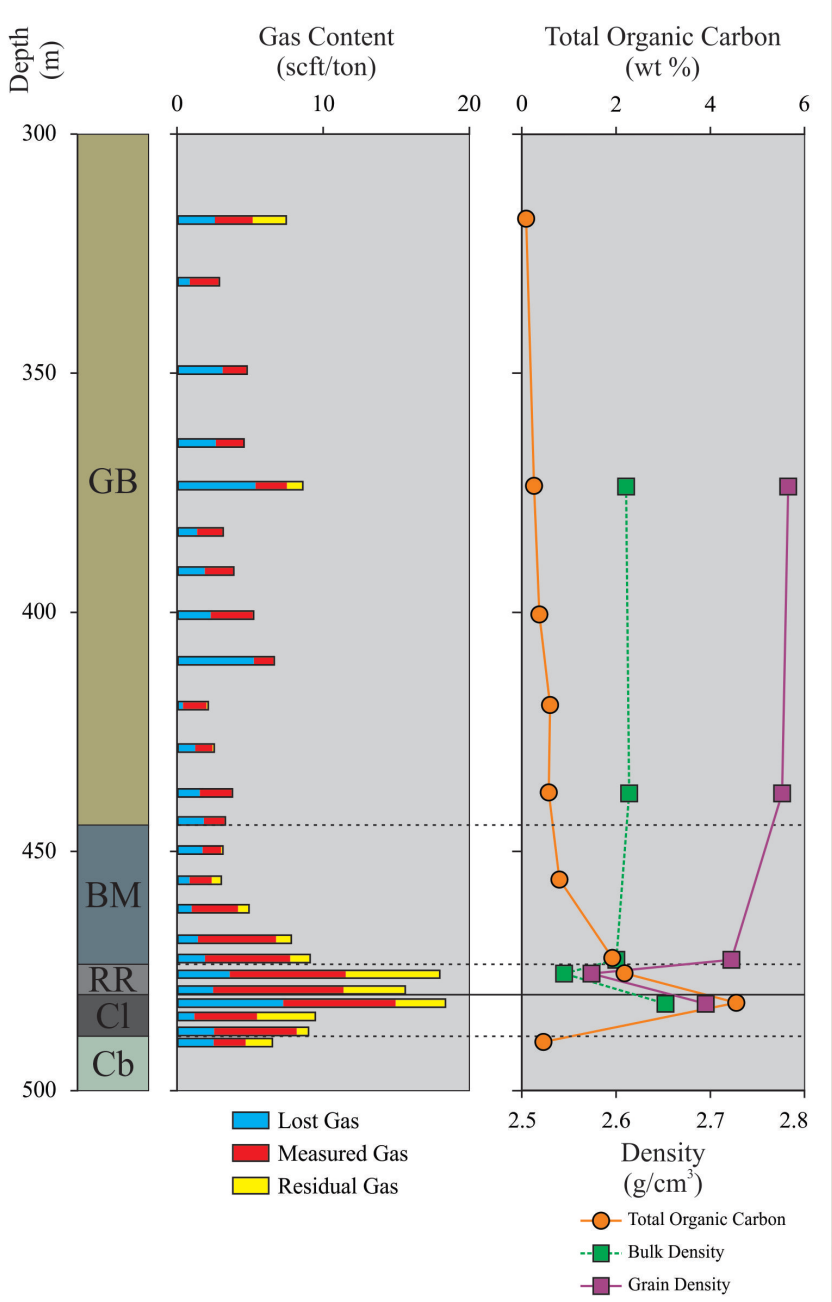
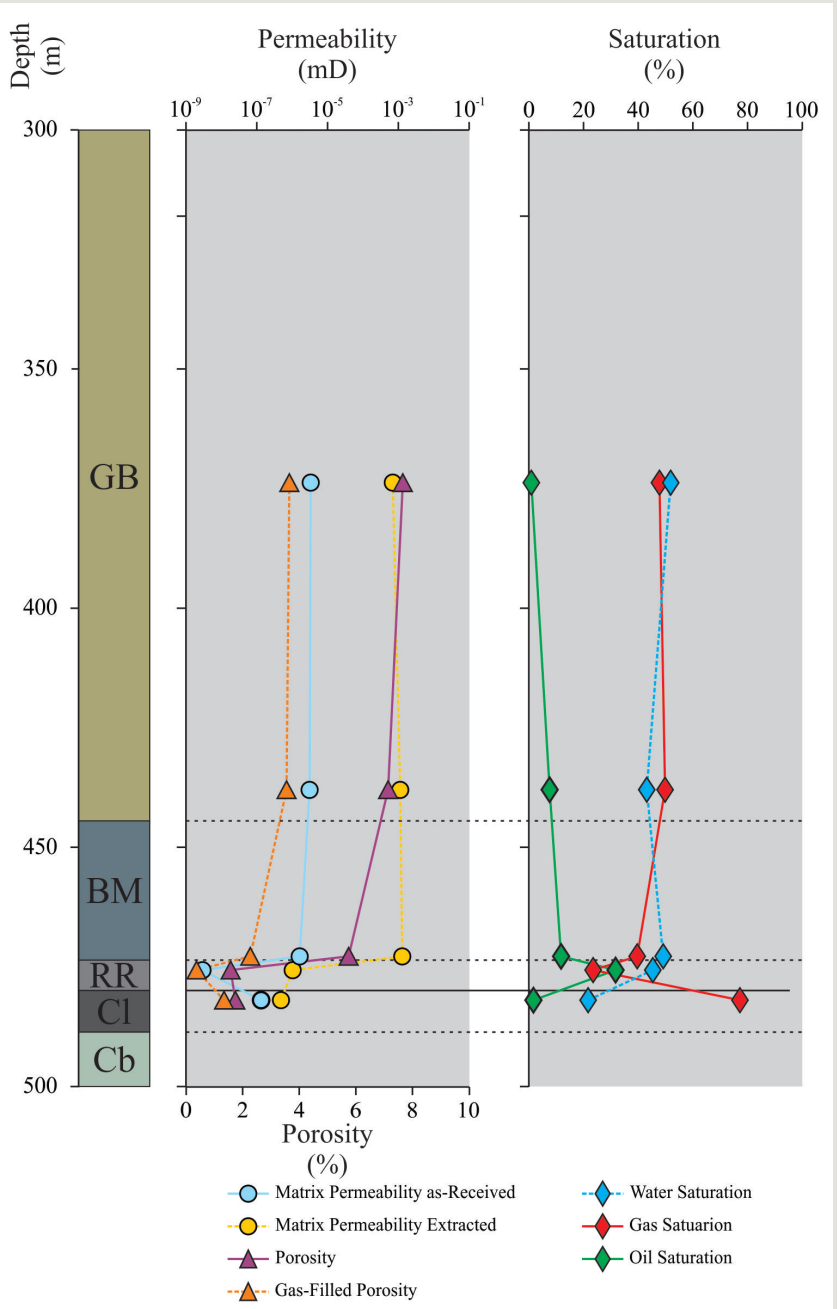
Results - Gas

- Gas content
  - General increase with depth (GB → RR + Cl)
  - Some higher value in GB associated to Ls beds
- Total organic carbon
  - General increase with depth (GB → RR + Cl)
  - Seems to influence gas content



Results - GRI



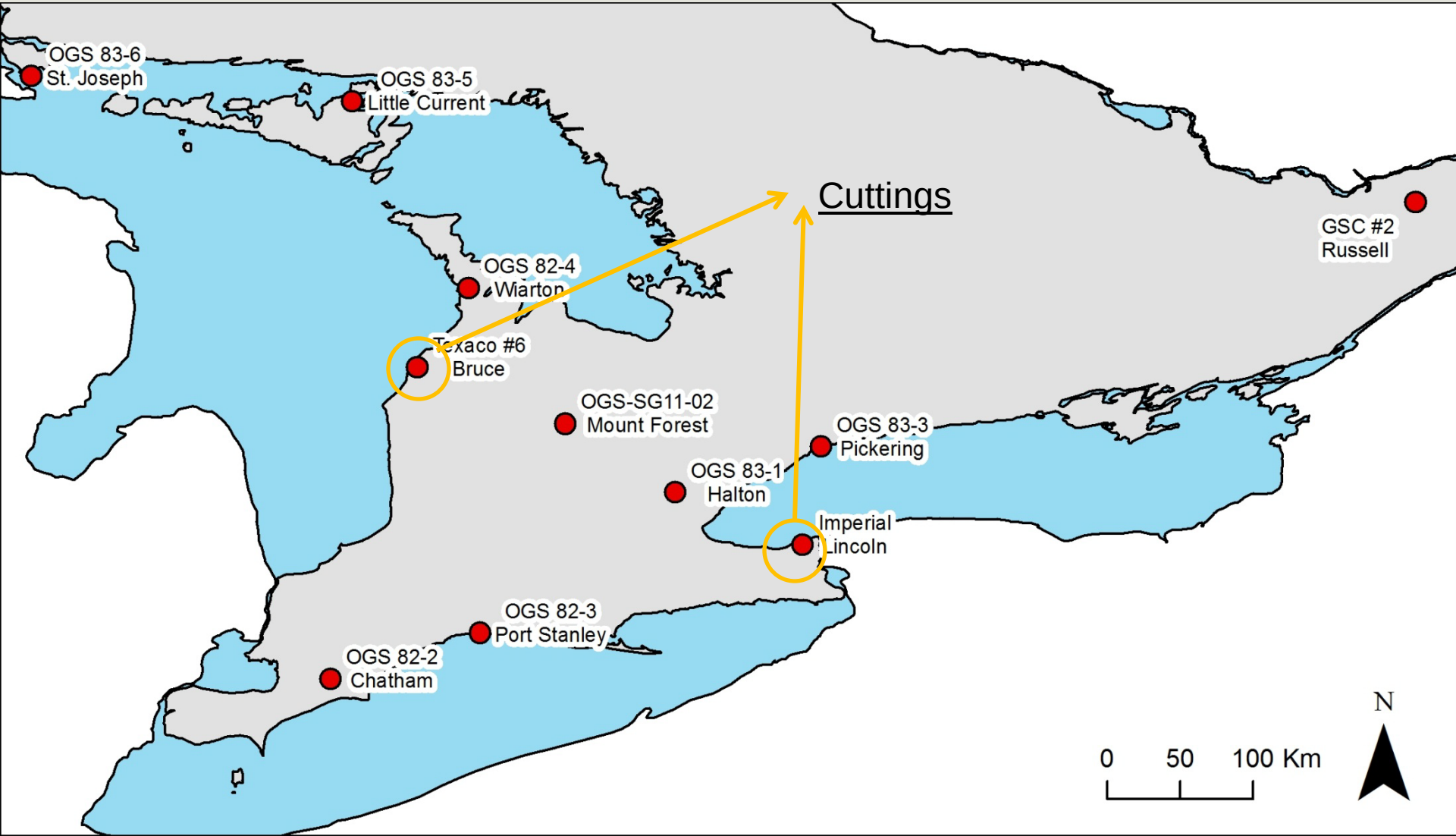
- Perm. / Porosity:
  - Decrease with depth from GB to RR
  - Increase in Cl (or Cb)
    - Limestone
- Saturations:
  - Oil: up to 31% in RR
  - Gas: up to 77% in Cl

Ontario

Sampling Program (2012)

- Regional study
- Establish
  - Thermal zones (if possible)
  - Richest intervals / areas
  - Depocenters, source of sediments
- Methodology
  - Sampling: 360 samples
    - 11 wells (Southern Ontario)
      - 9 cores, 2 cuttings
  - Analyses:
    - XRD
    - Rock-Eval^{6} pyrolysis

Sampling Program (2012)



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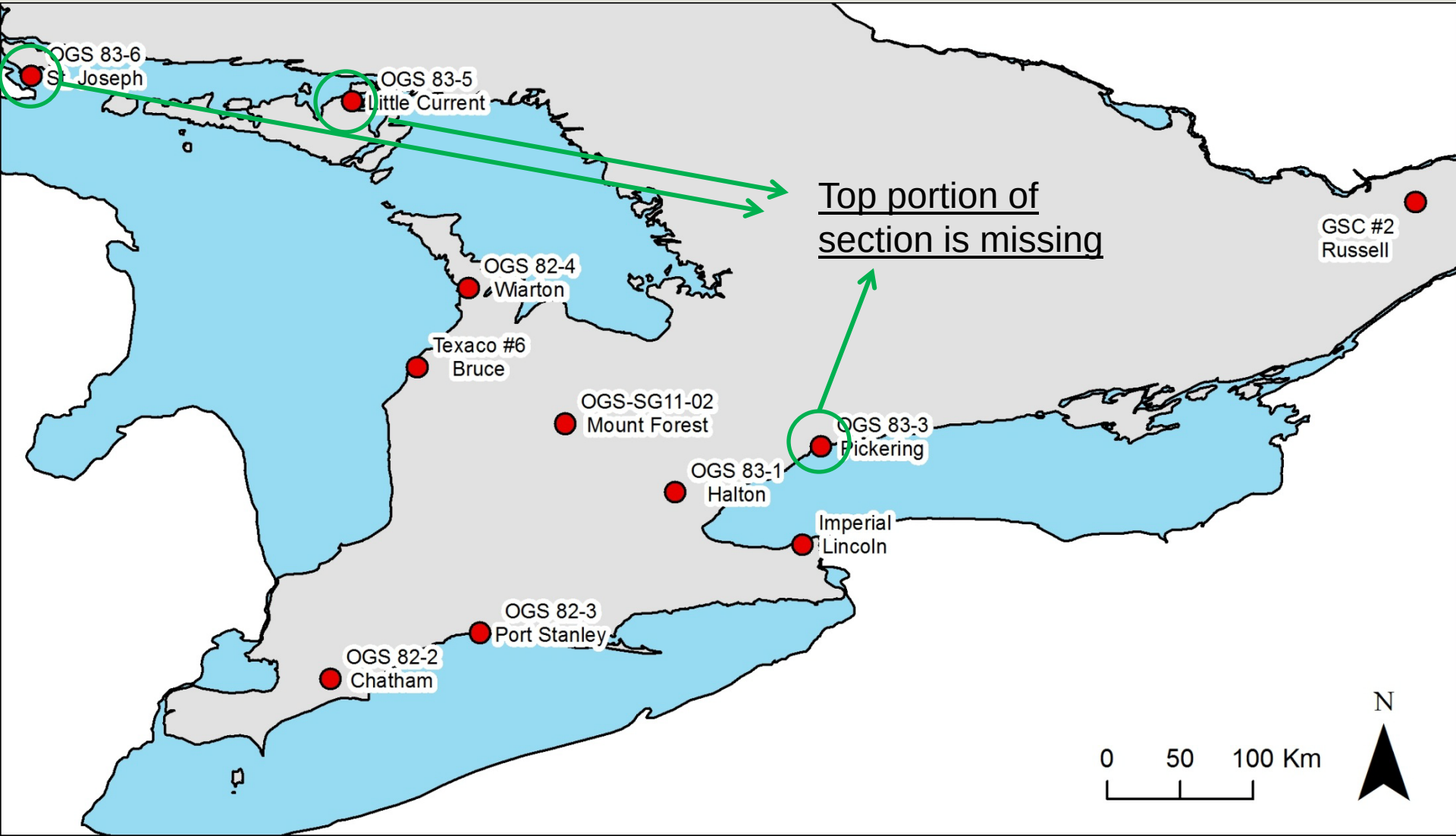

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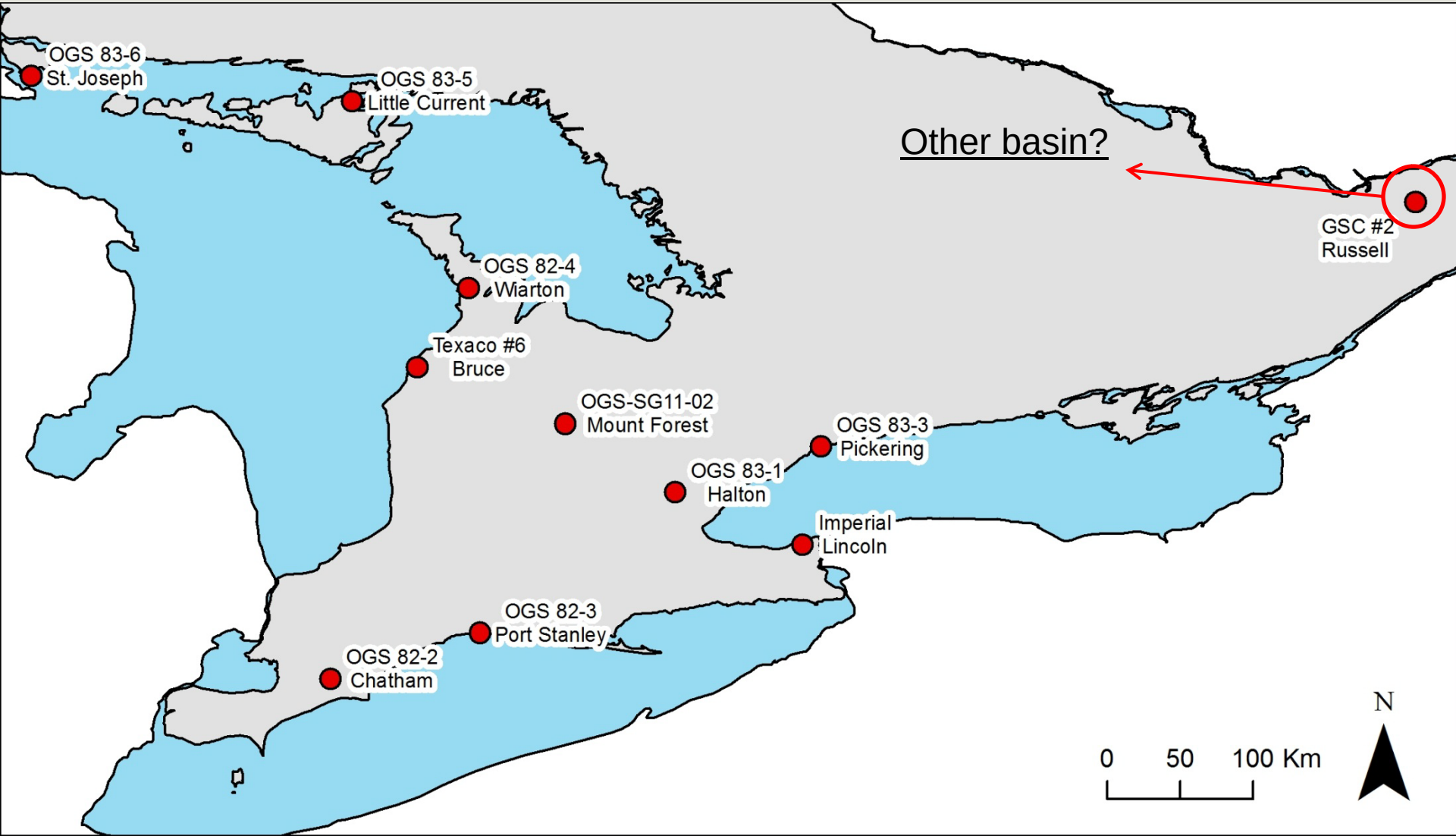
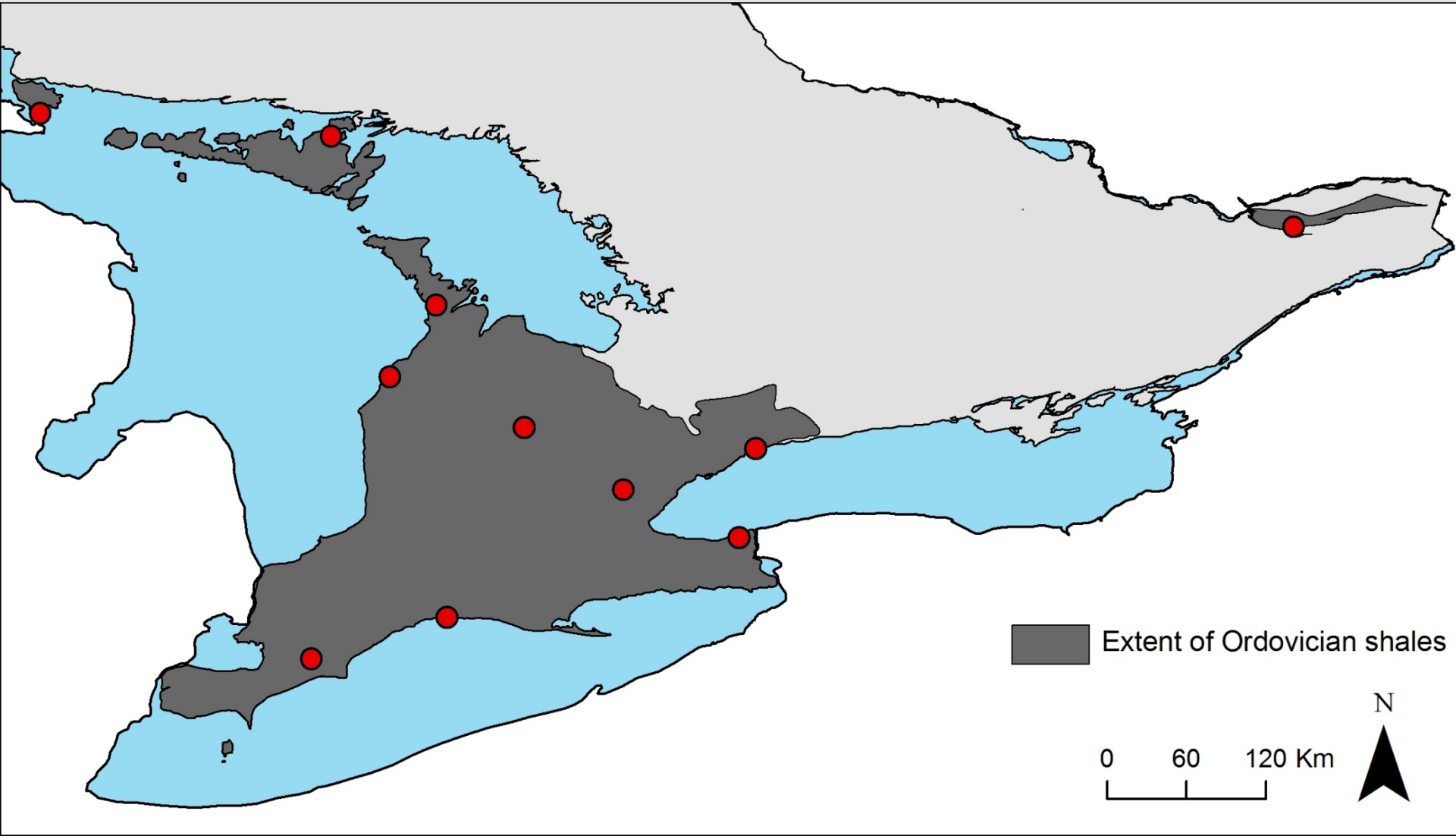
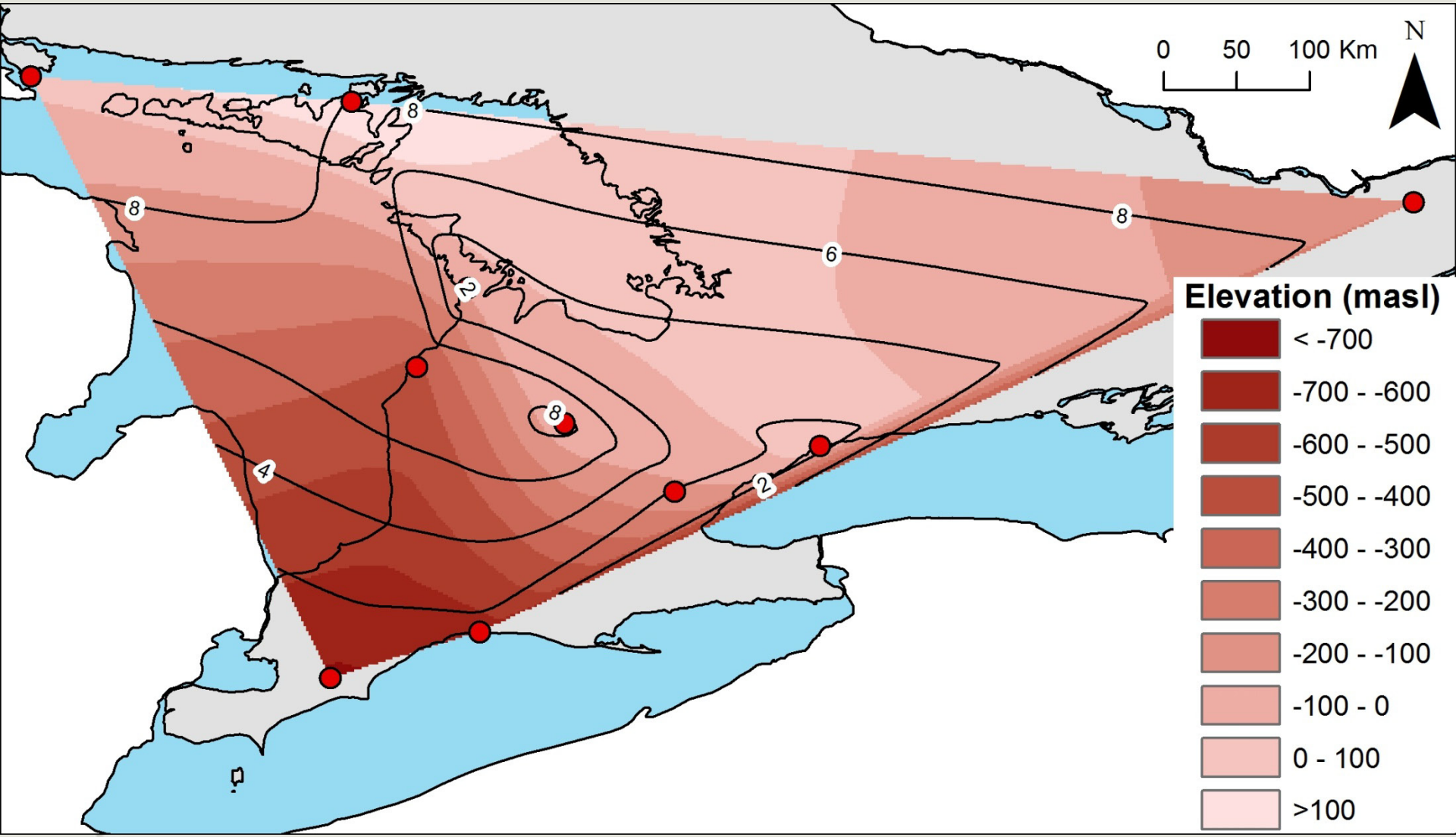


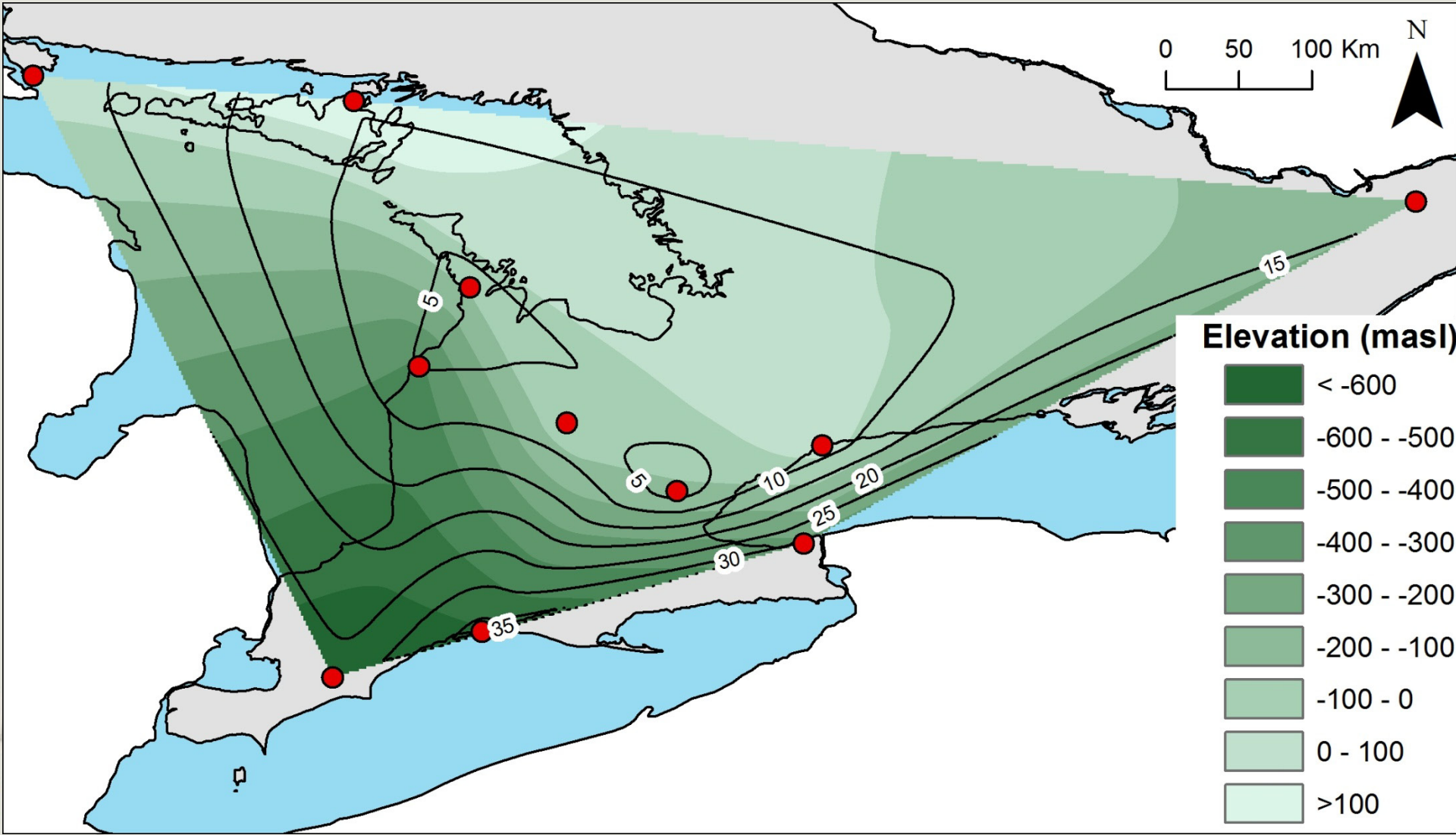
Extent of Ordovician Shales



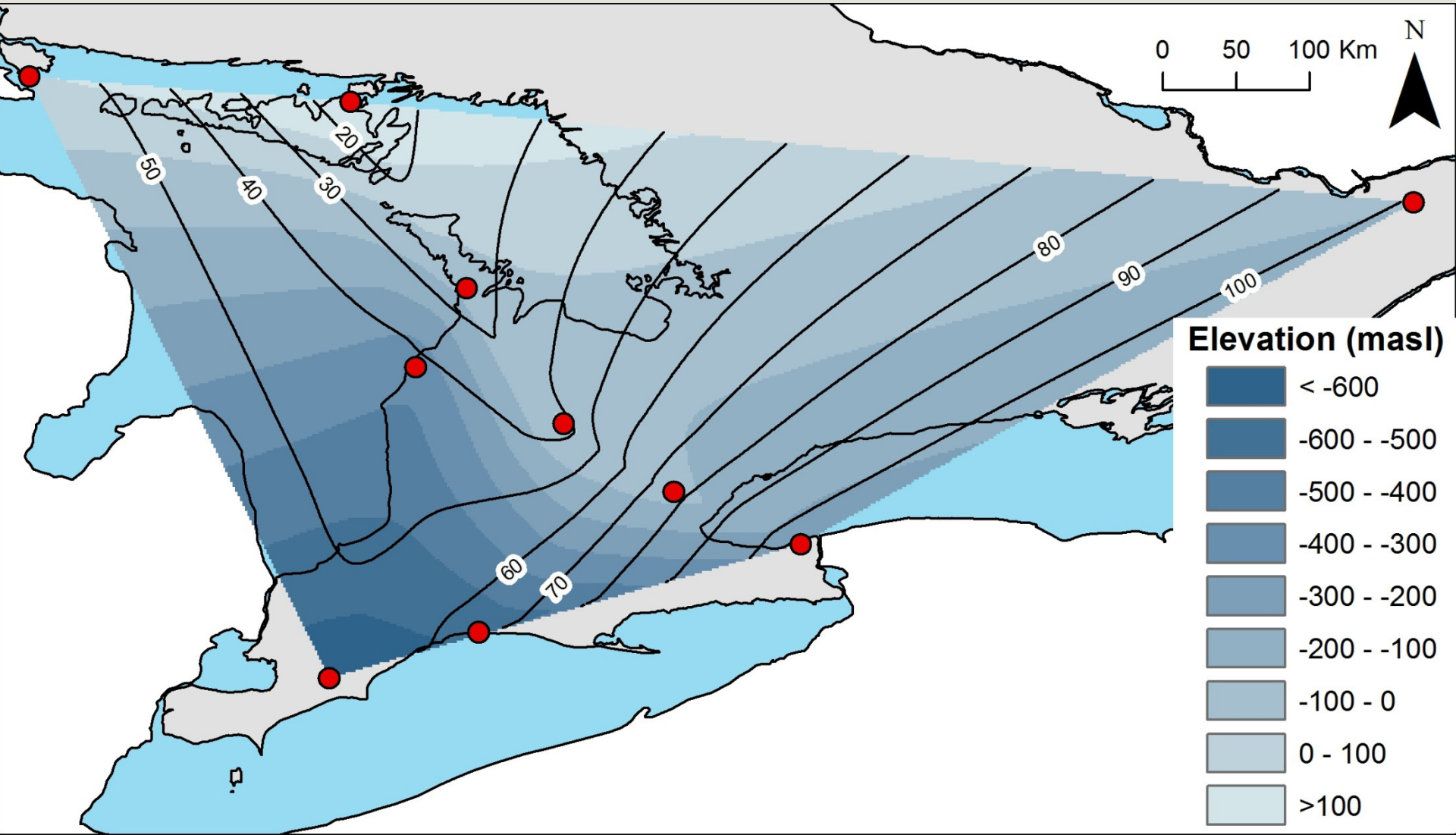
Thickness of Collingwood Mb Initial *"cleaned"* data



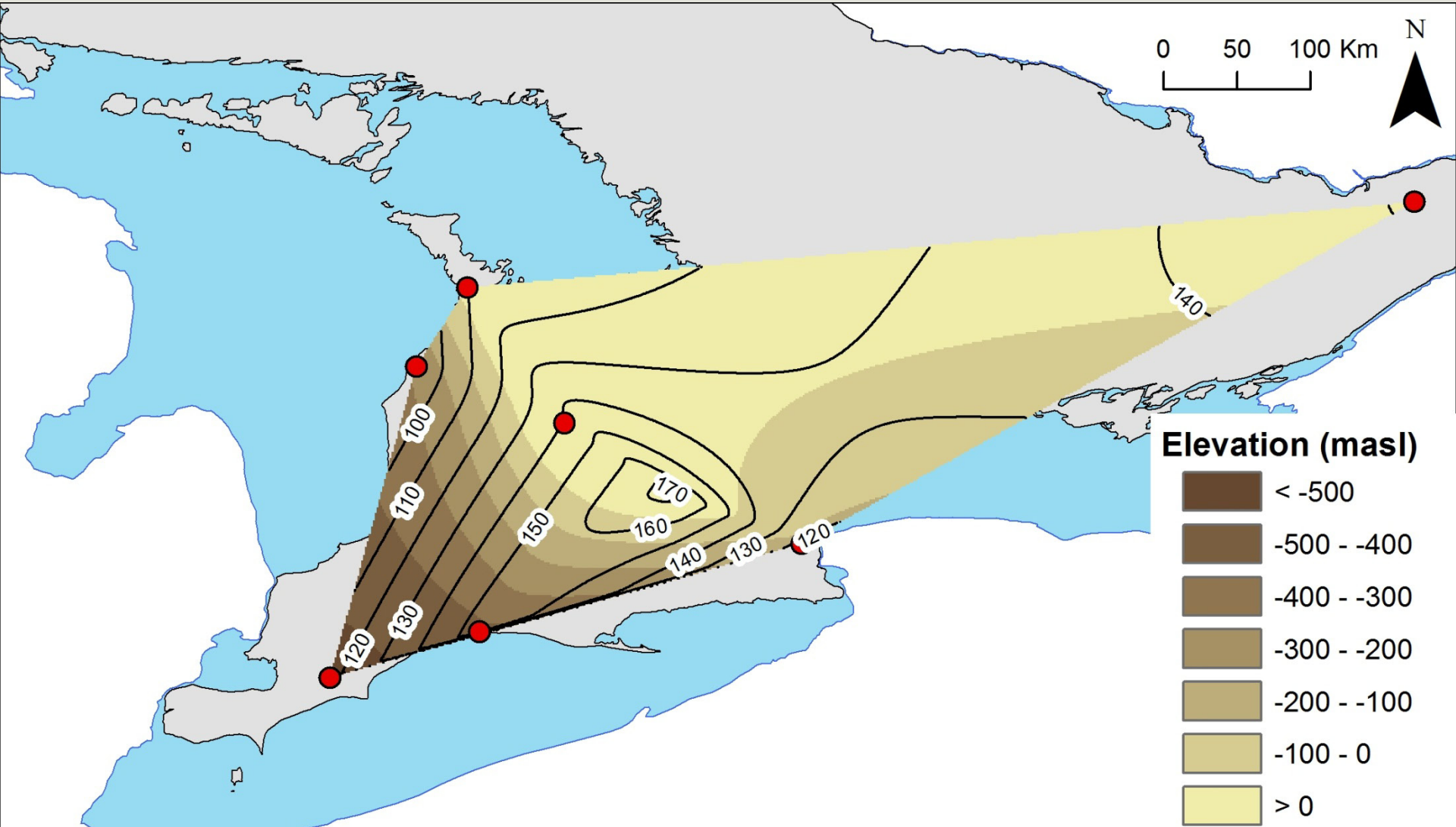
Thickness of Rouge River Mb Initial data



Thickness of Blue Mountain Fm Initial data



Thickness of Georgian Bay Fm Initial data



Conclusions

- Ordovician stratigraphy
  - Definition of lithologic contacts may change when XRD and Rock-Eval[6] pyrolysis results come in.
- Hydrocarbon potential
  - Definitely more potential for the Rouge River and Collingwood members.
    - TOC
    - Gas content
    - Hydrocarbon saturations
  - Different character between RR/ Cl

Conclusions

- Regional maps – initial data
  - Collingwood:
    - Increase of thickness to the north
    - Platform
  - Georgian Bay and Blue Mountain Fms:
    - Increase of thickness to the SE
    - Appalachian origin
  - Future XRD and RE data may confirm this