

Hydrocarbon Resources in the Upper Ordovician Black Shales in Quebec (Eastern Canada): From Gas/Condensate in the Utica to Oil in the Macasty*

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Abstract

In Eastern North America, a 50 - 300 m-thick regional blanket of Upper Ordovician organic matter-rich limy shales extends for over 2,500 km, from Ohio to western Newfoundland. The succession is known as the Utica (Ohio, New York, and southern Quebec) and the Macasty (eastern Quebec) Shale. Regionally, the thermal maturation of the shales is highly variable, going from dry gas to oil windows and is controlled by a complex burial history involving Taconian, Acadian and Alleghenian tectonic wedges.

The Upper Ordovician Utica Shale (50 to 300 m thick) and Macasty Shale (50 to 100 m thick) are found in southern Quebec and Anticosti Island, respectively. The Utica and Macasty limy shales overly the Ordovician carbonate foreland platform; the calcareous shales started to accumulate when, because of rapid increase of relative sea level rise, the backstepping carbonate producing zone was partially shut down leaving siliciclastic muds with subordinate carbonate mud to accumulate in an interpreted poorly oxygenated marine setting. Largely unknown basin configuration resulted in variation in thickness and lateral character of the sedimentary accumulations whereas the variations in the vertical succession resulted from yet to demonstrate, higher frequency sea-level fluctuations. Both shales have been deformed during the Late Ordovician Taconian Orogeny although if the degree of deformation was relatively minor, it increases significantly with structural thickening in the Appalachian domain. Previous works on the source rock potential of the Utica and Macasty shales has led to a regional understanding of the distribution of thermal domains. The Utica Shale (TOC up to 3%) in southern Quebec is in the oil/wet gas domain at the northeastern end of the exposed Ordovician platform although for most of this geological domain, the Utica is within the dry gas zone. The Macasty Shale (TOC up to 5%) in Anticosti Island straddles the oil and wet gas windows. Twenty-three shale gas exploration wells have been drilled since 2007 in the Utica Shale resulting in the successful production testing of significant volume of natural gas after multistage fracturing. Current best estimates indicate original gas-in-place values between 120 and 140 Tcf. Historical geological data and recent core analyses indicate that the

Macasty Shale could represent a shale oil target in Anticosti Island and current best estimates suggest original oil-in-place values of about 45 BBO.

Selected References

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Lavoie, D., N. Pinet, M. Duchesne, A. Bolduc, and R. Larocque, 2010, Methane-derived authigenic carbonates from active hydrocarbon seeps of the St. Lawrence Estuary, Canada: *Marine and Petroleum Geology*, v. 27/6, p. 1262-1272.

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Outline

1. Introduction
2. Regional geological context of the Upper Ordovician shale basin in Quebec
3. GSC preliminary in-place resources (liquid and gas) for the Utica
4. Industry in-place resources (liquid) for the Macasty
5. A 800 km-long liquid-rich domain from Southern Quebec to Anticosti Island ?



North American shale plays (as of March 2011)

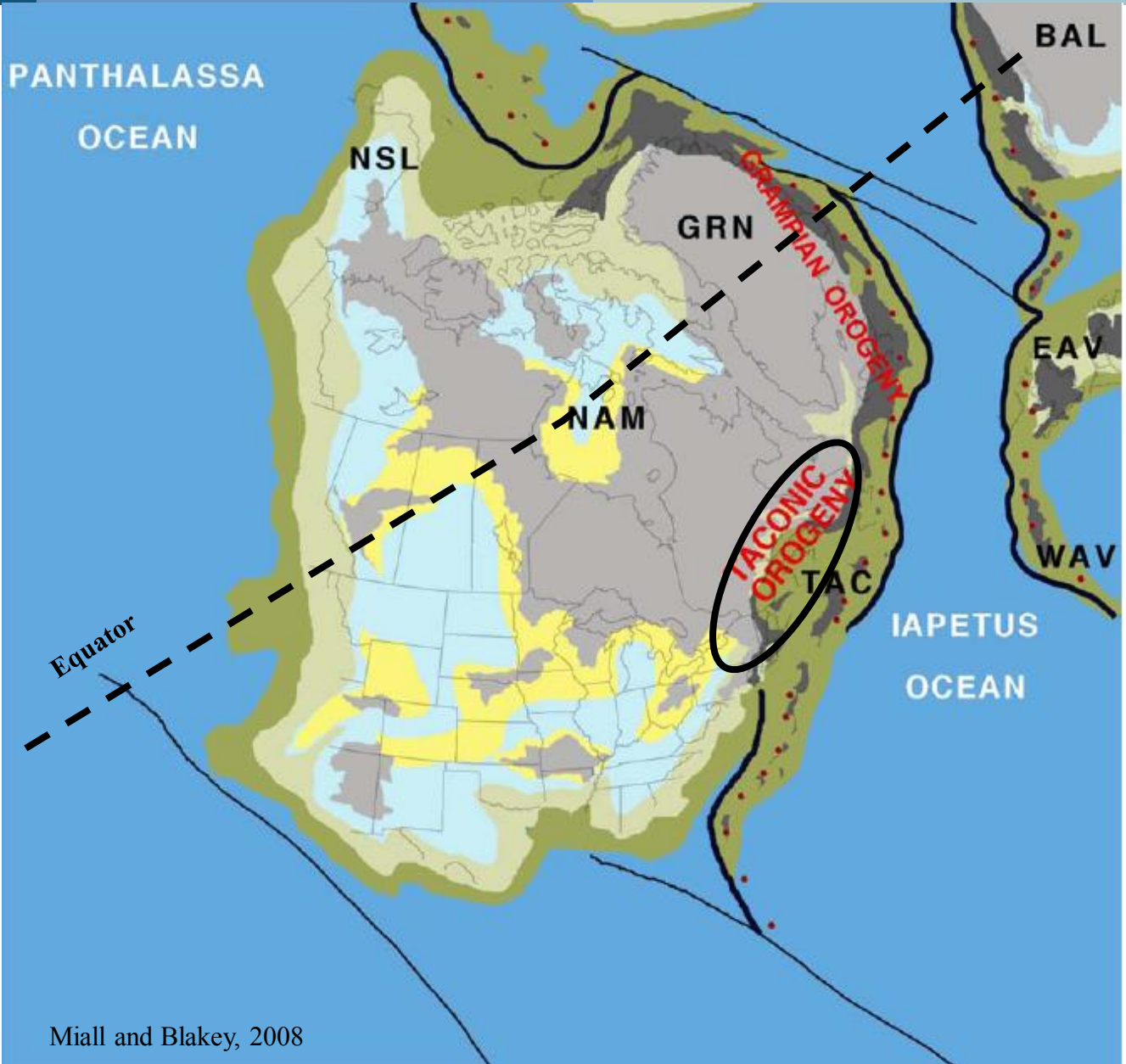


REGIONAL GEOLOGICAL CONTEXT

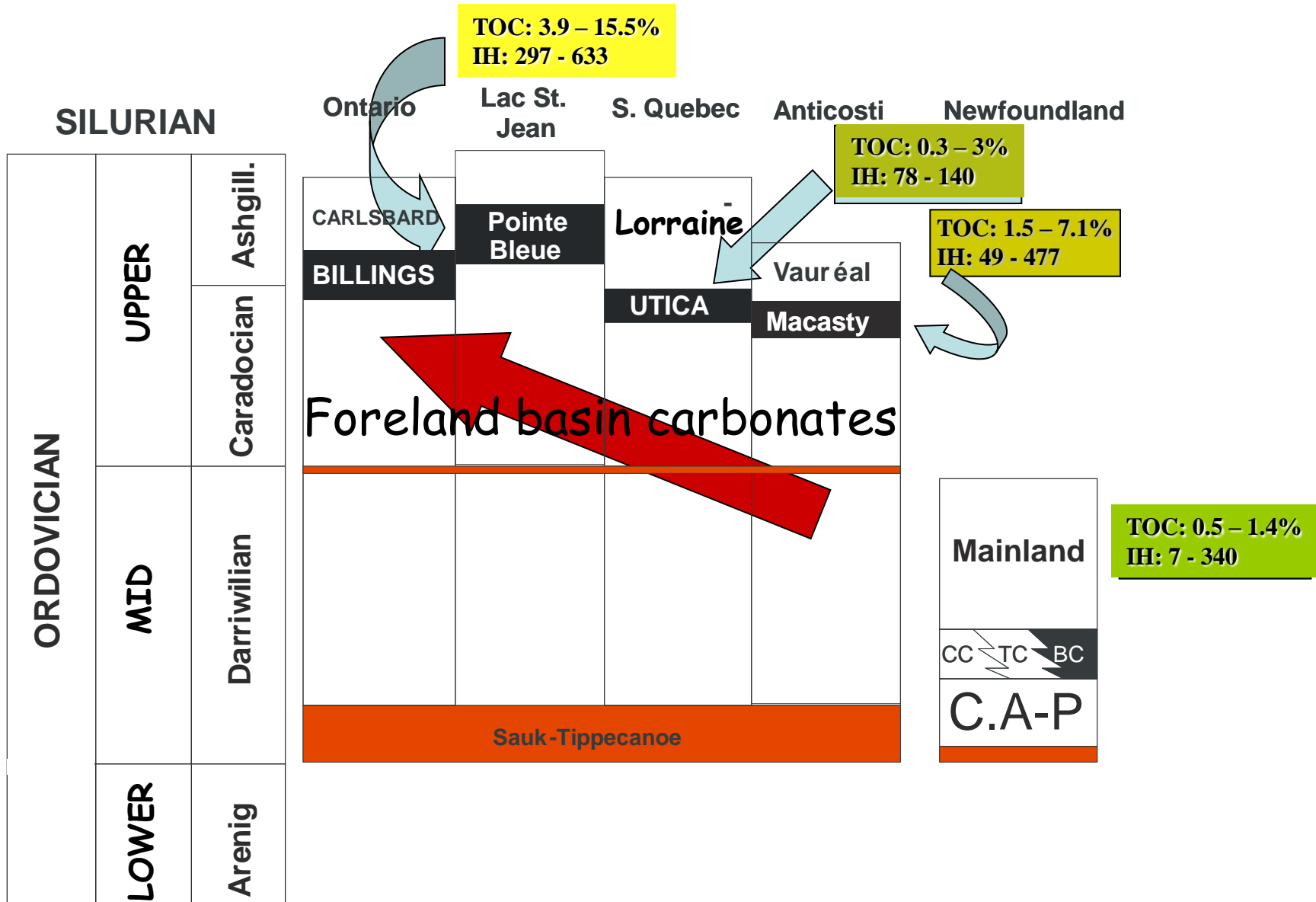


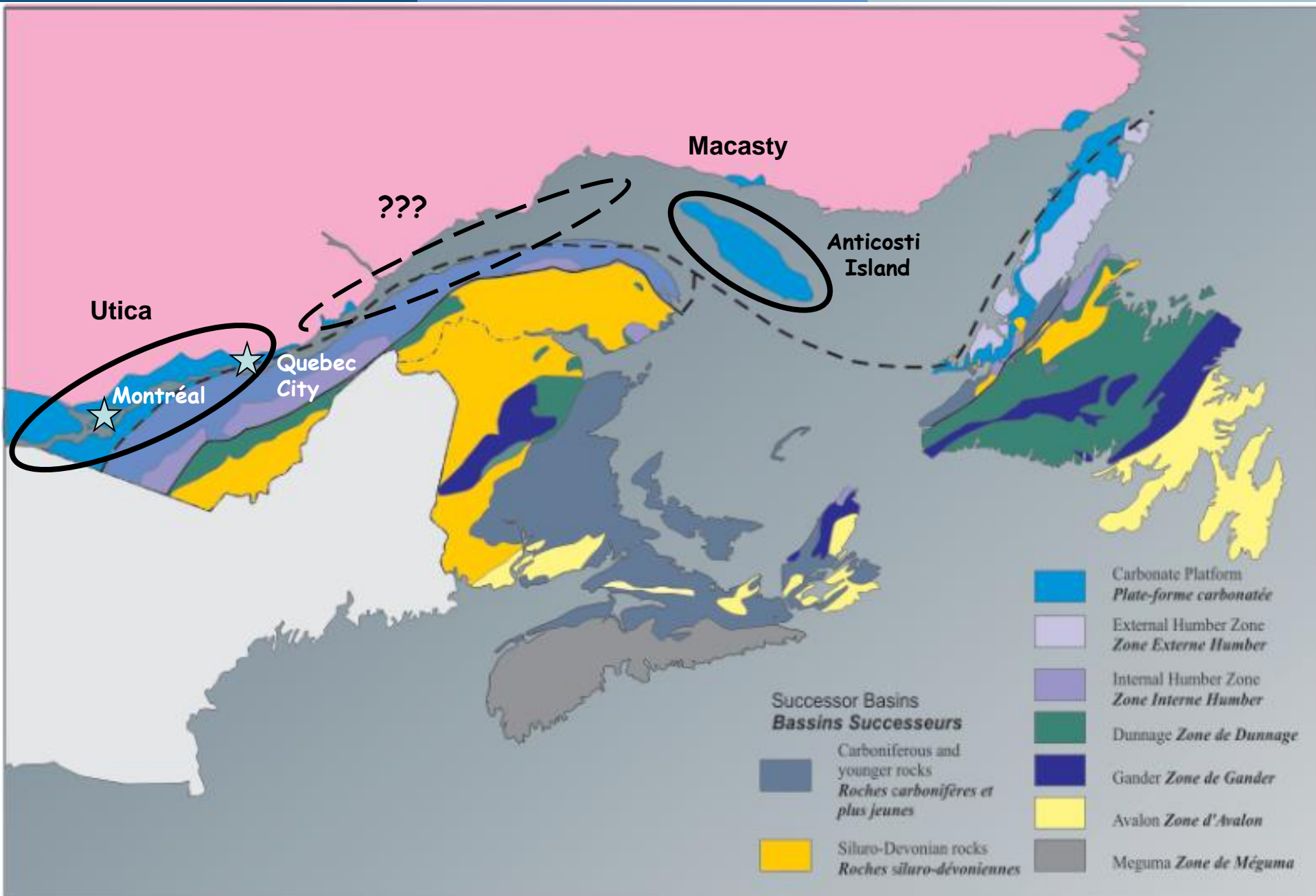
Mid to Late Ordovician

Formation of a tectonic foreland basin

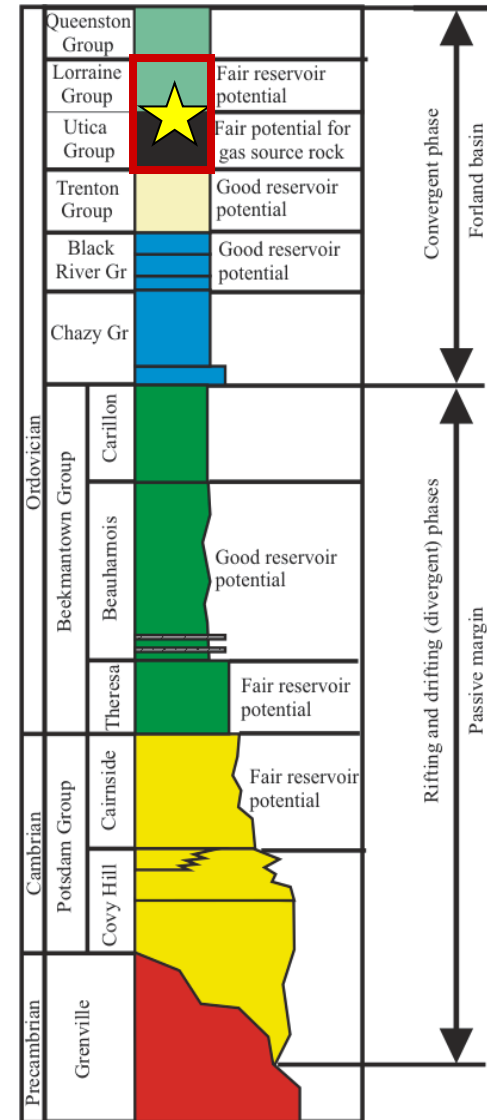
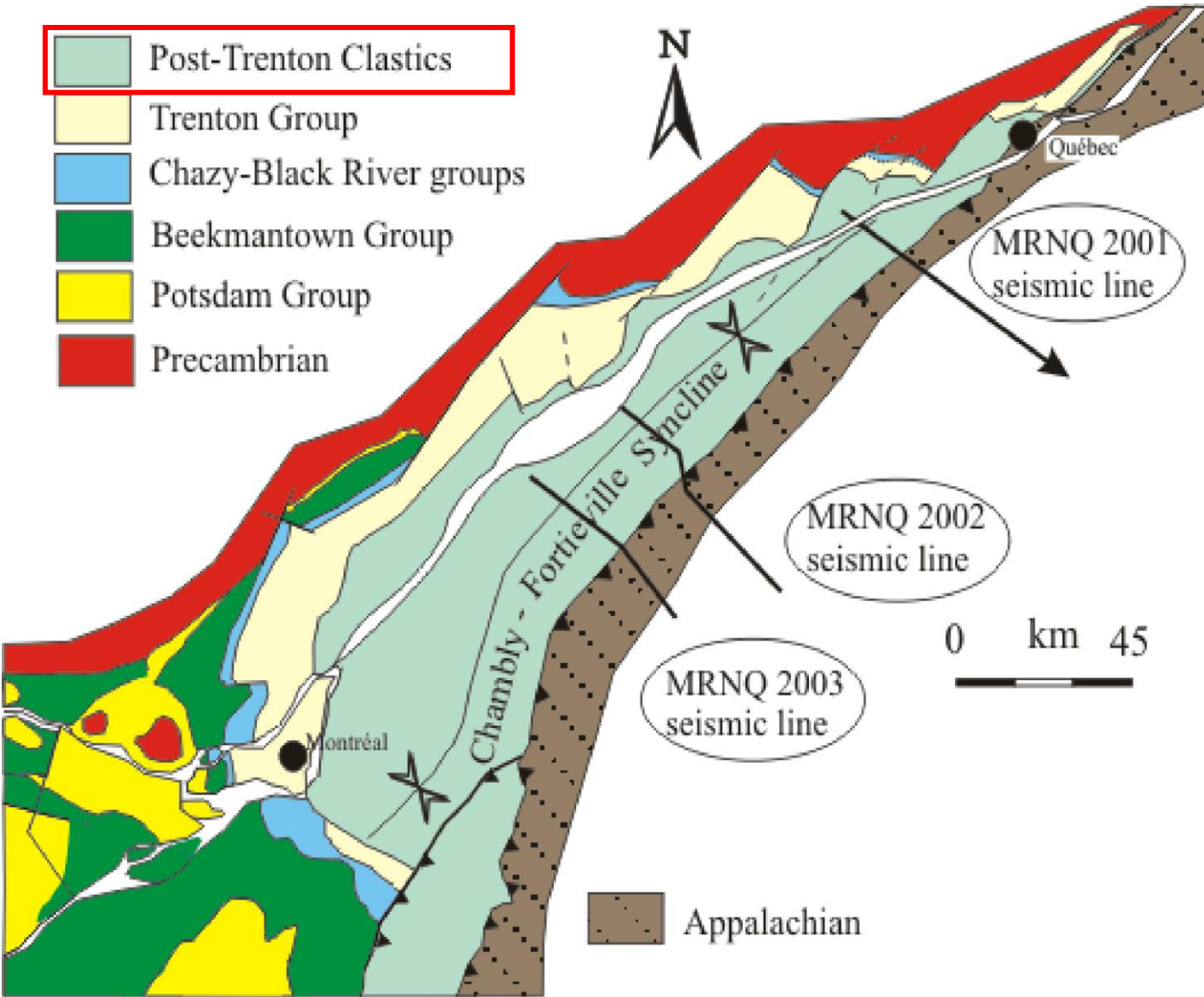
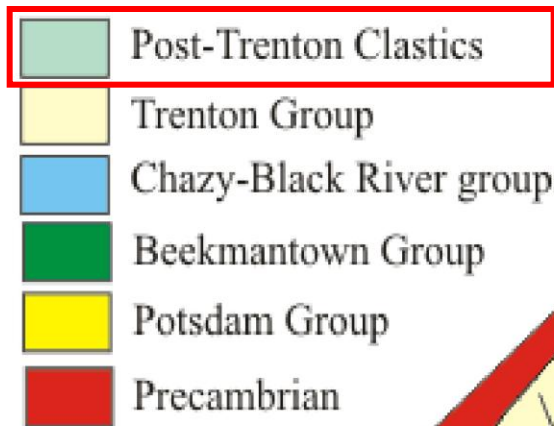


Ordovician black shales in eastern Canada

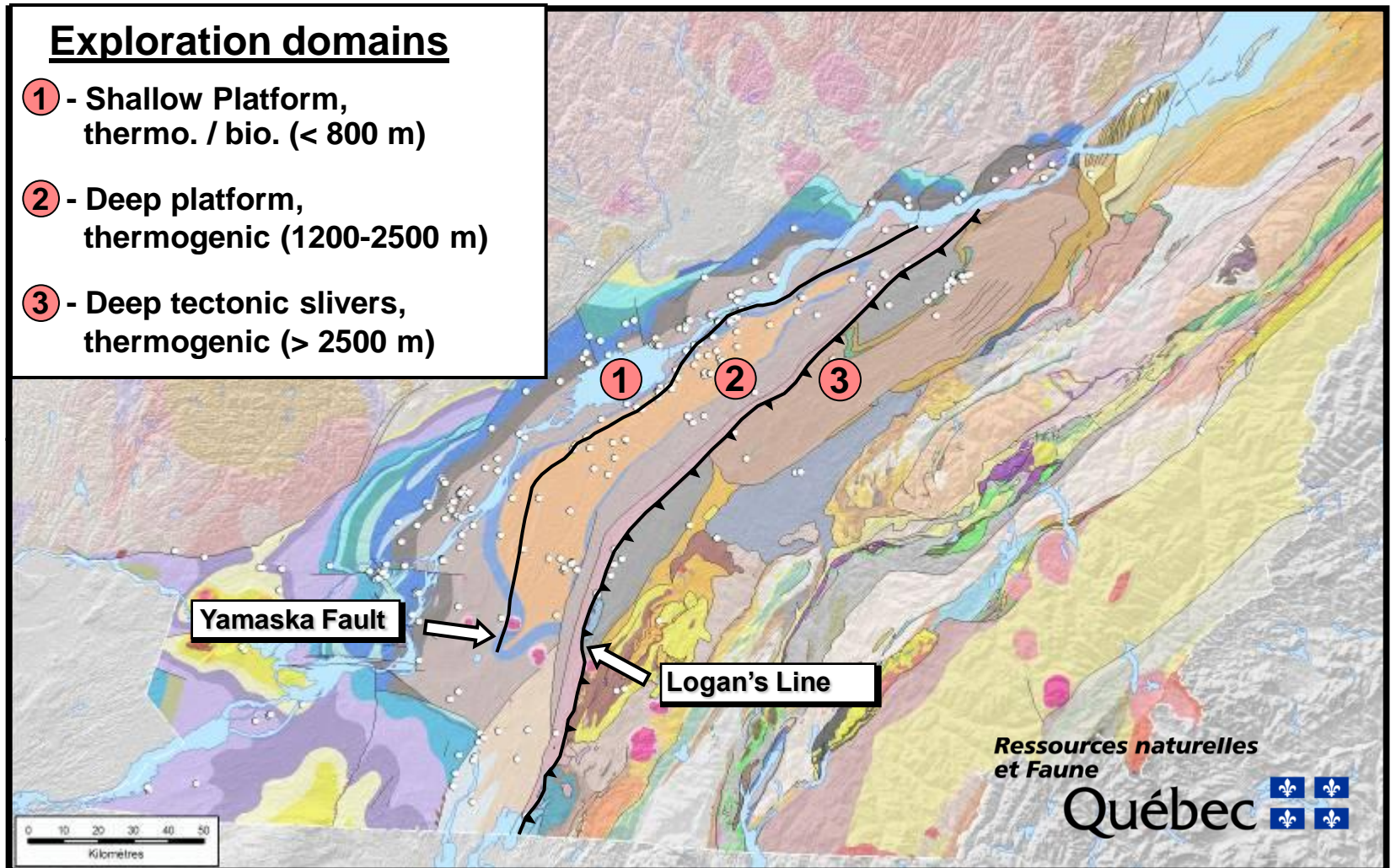




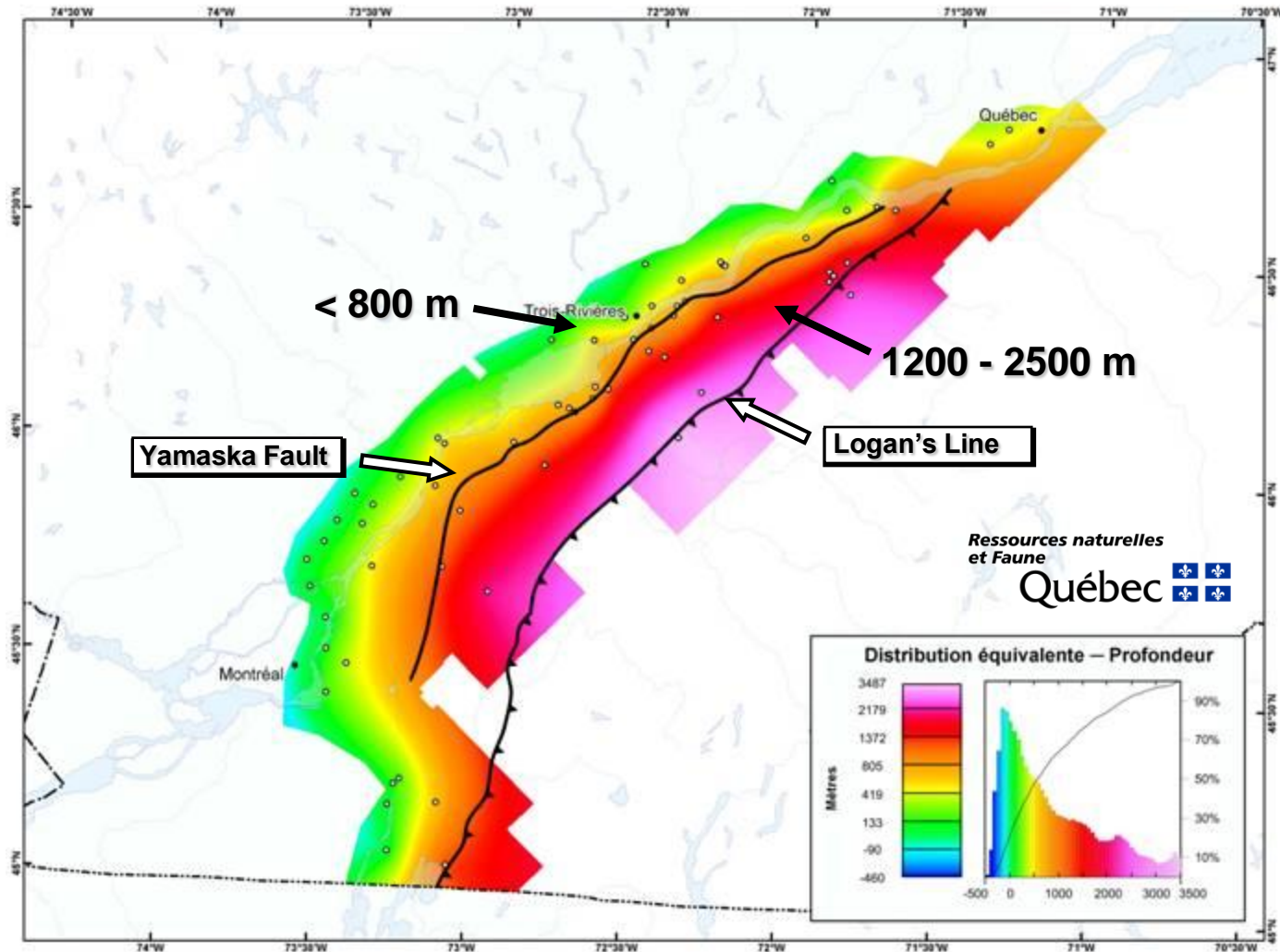
Upper Ordovician foreland clastics - Southern Quebec



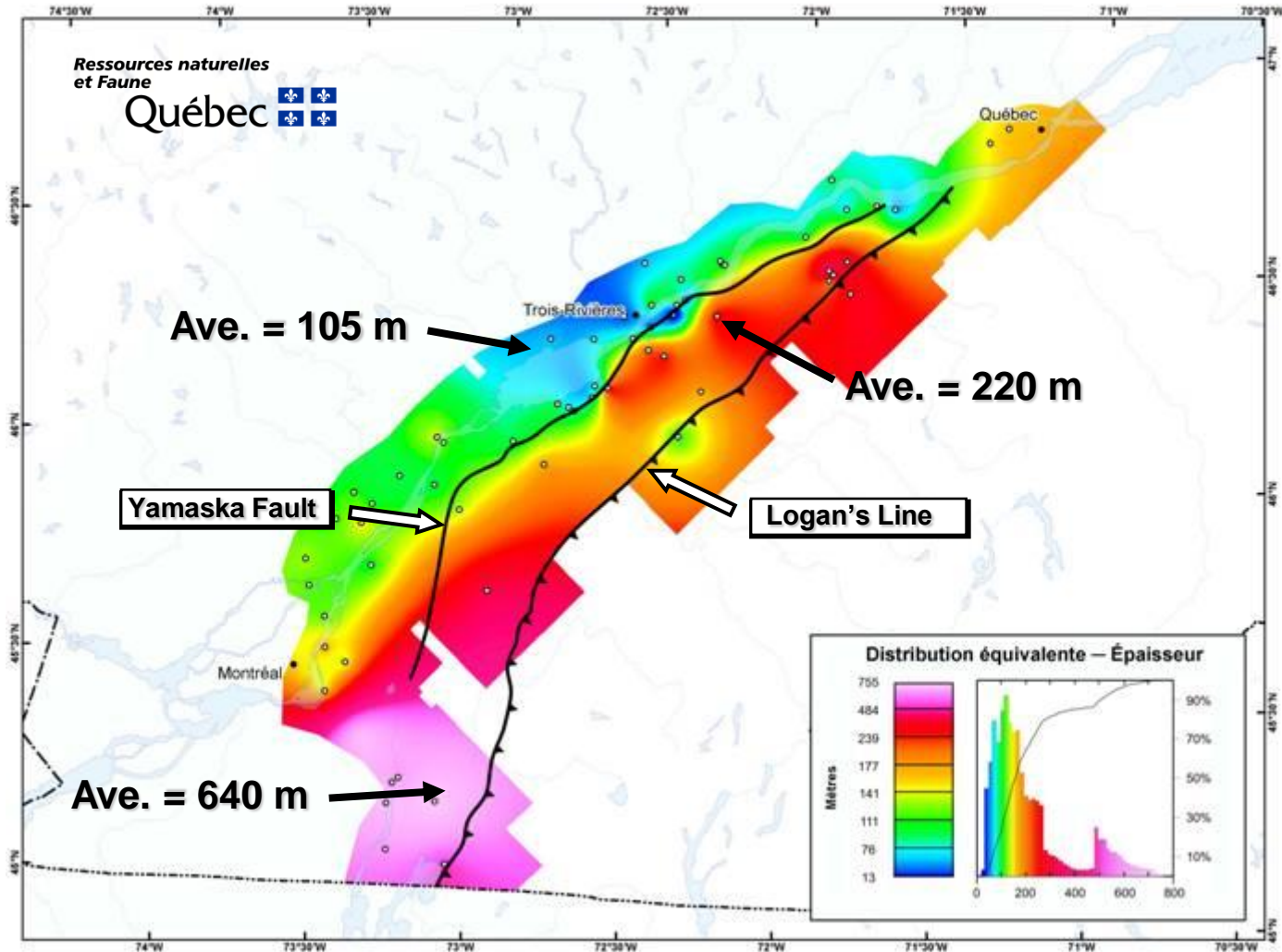
THE CURRENT STATUS OF PUBLIC DOMAIN DATA

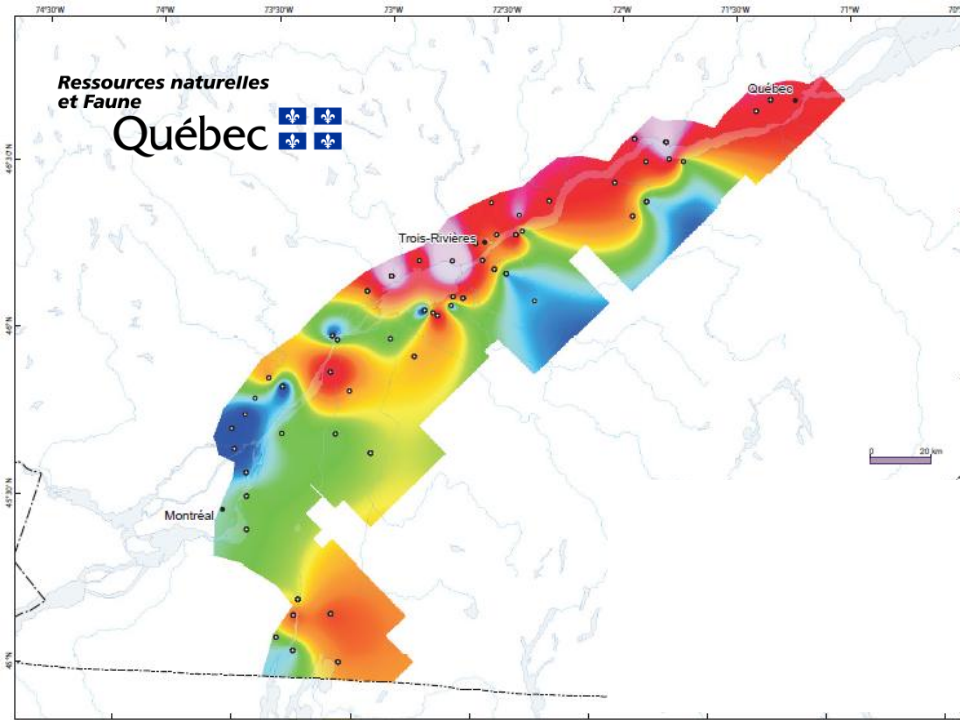


Depth to the top of the Utica Shale



Thickness of the Utica Shale





S1 Index

mg HC / g rock

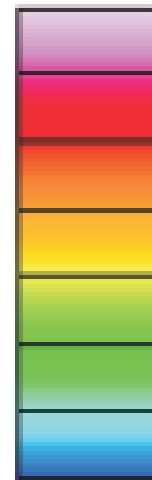
0.7

0.3

0.2

0.1

0



Lower Utica

Upper Utica



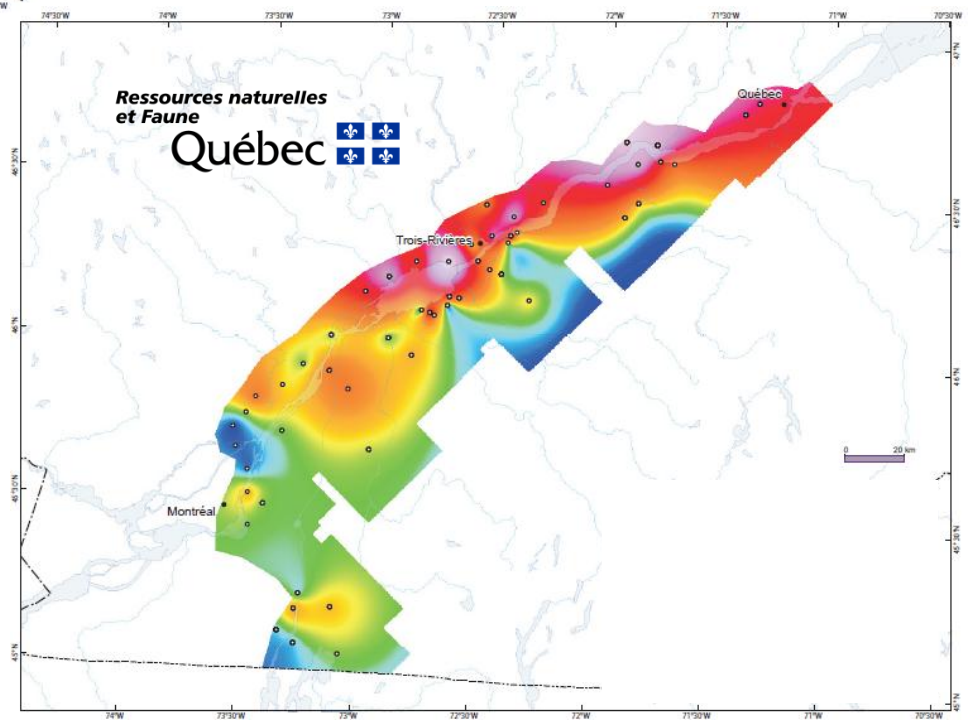
mg HC / g rock

(Thériault, 2012)



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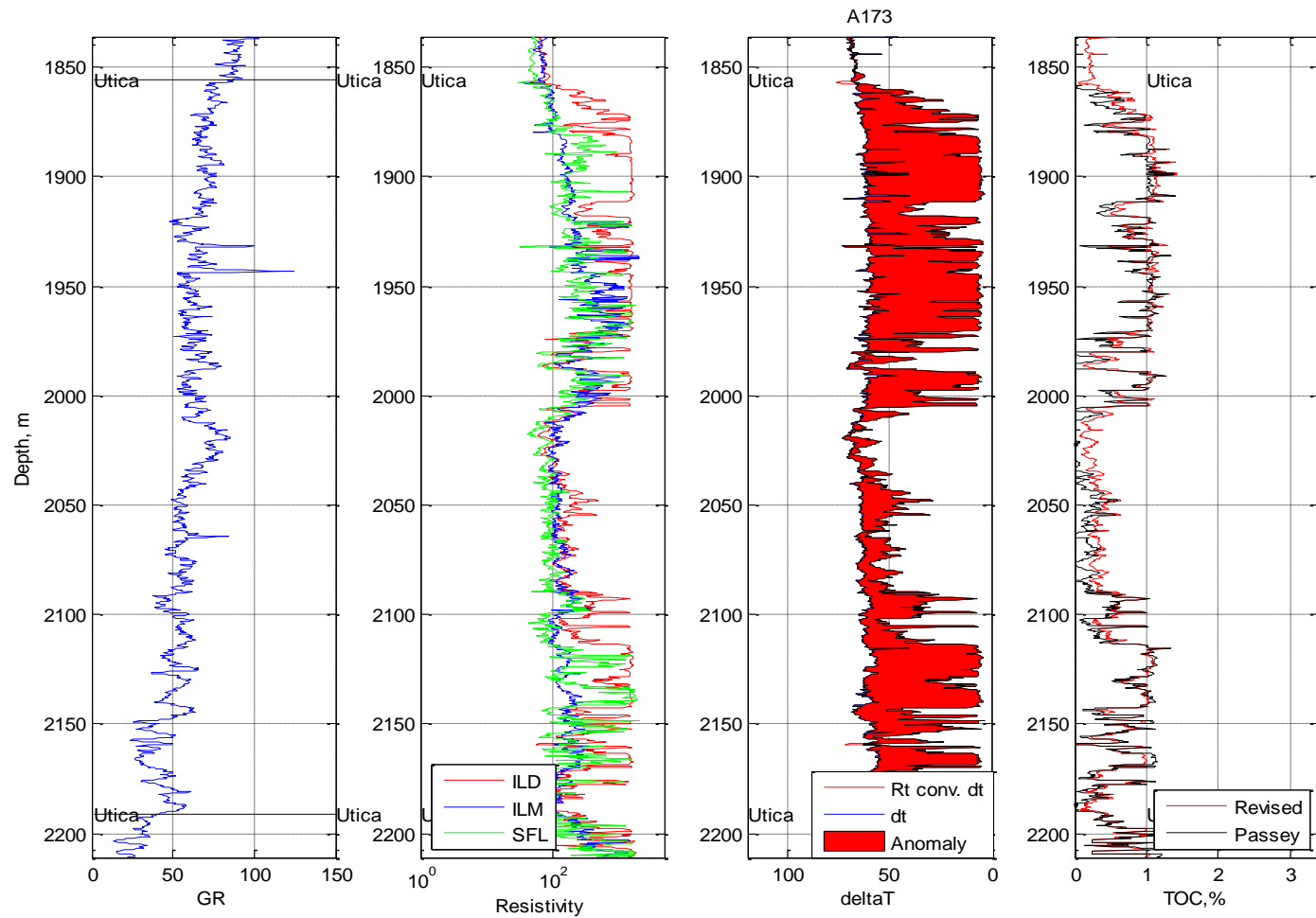


Preliminary in-place resource evaluation Utica Shale in southern Quebec

- Well log data from 44 exploration wells
- Interpretation (calculation) models for estimating
 - hydrocarbon bearing interval thickness
 - porosity
 - hydrocarbon saturation
- Kinetic and maturity models from organic geochemistry
- Formation volumetric
 - Formation thickness of Utica
 - Areal extent of Utica

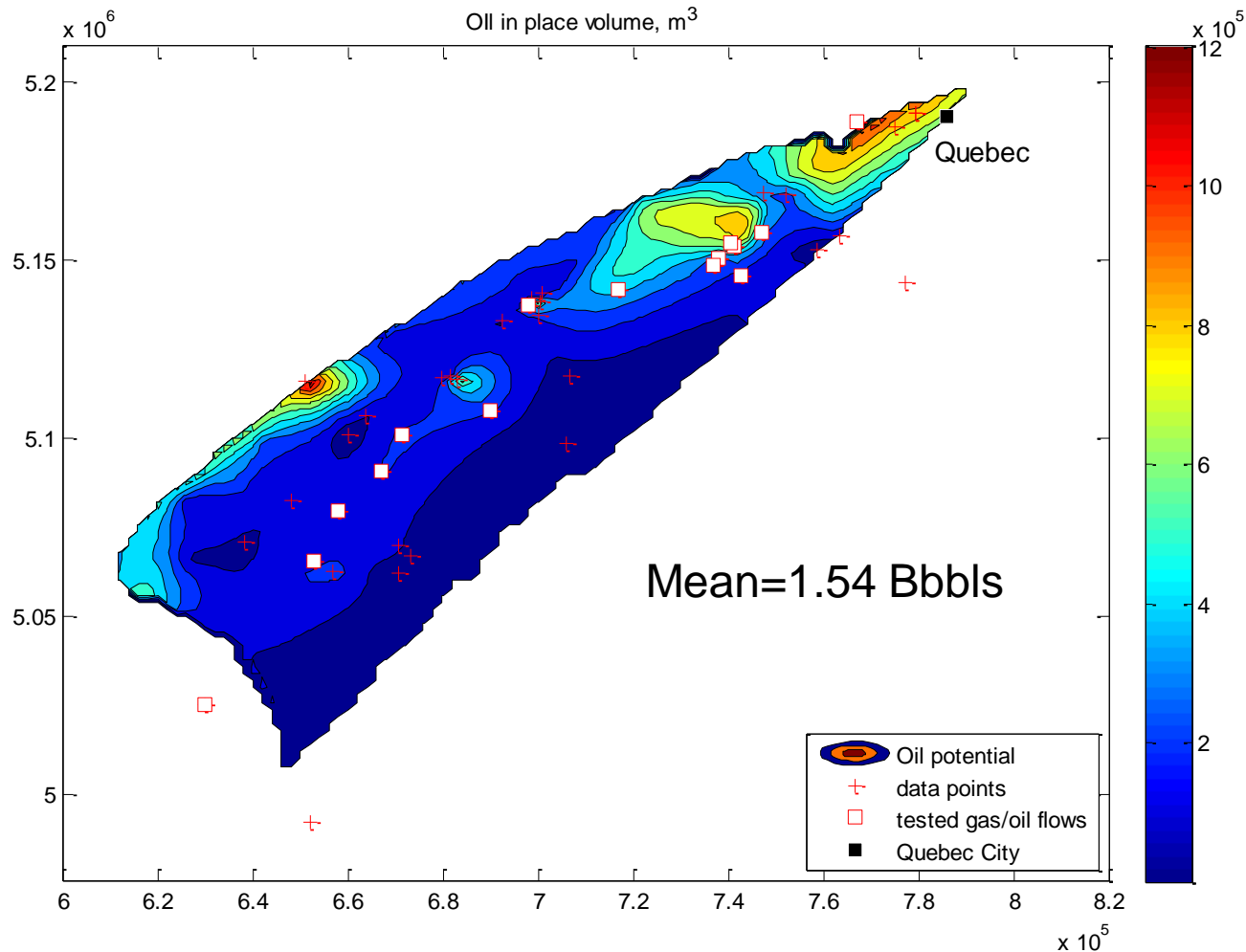


Well log responses, A173



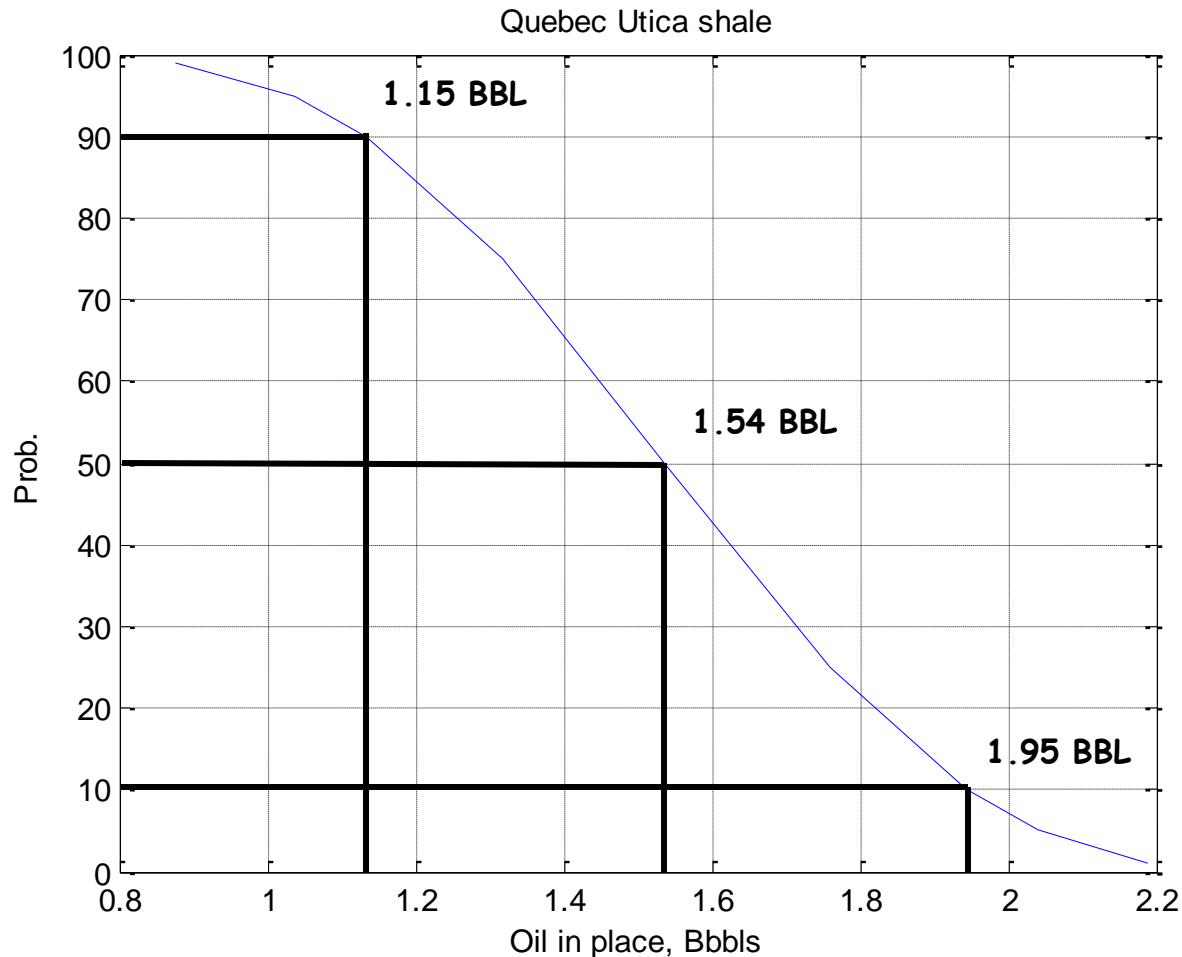
Liquids in place (P50), Quebec Utica

PRELIMINARY



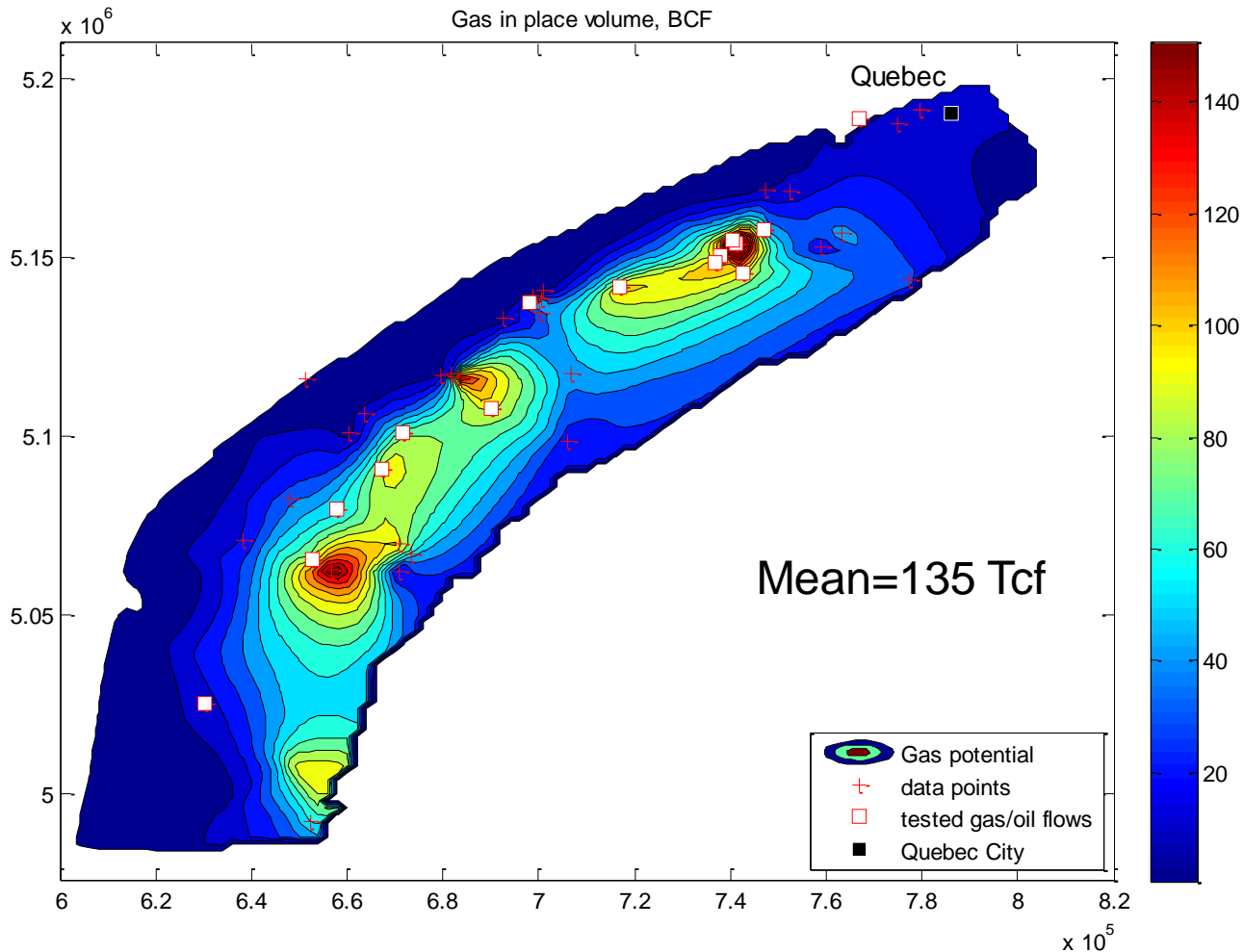
Cumulative distribution of estimated liquids in place

PRELIMINARY



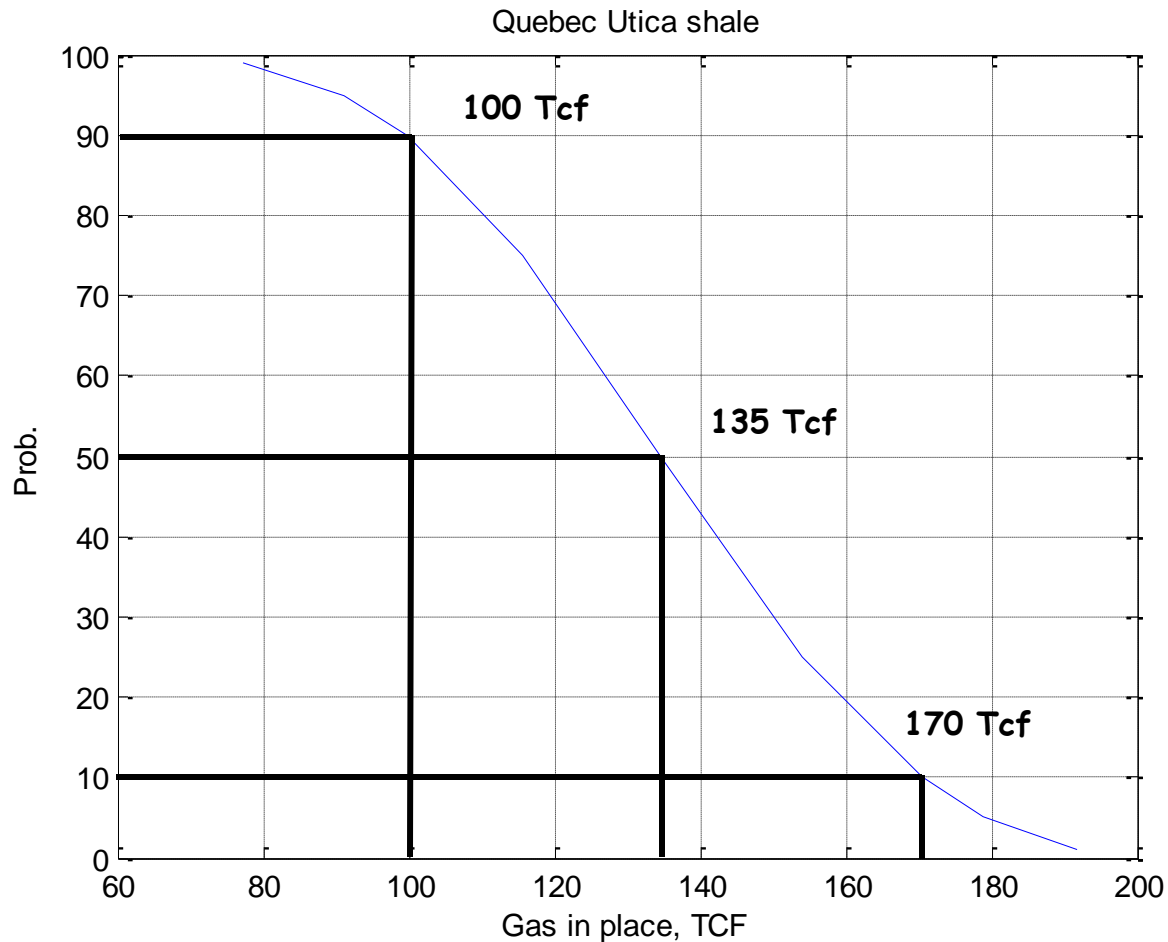
Gas in place (P50), Quebec Utica

PRELIMINARY

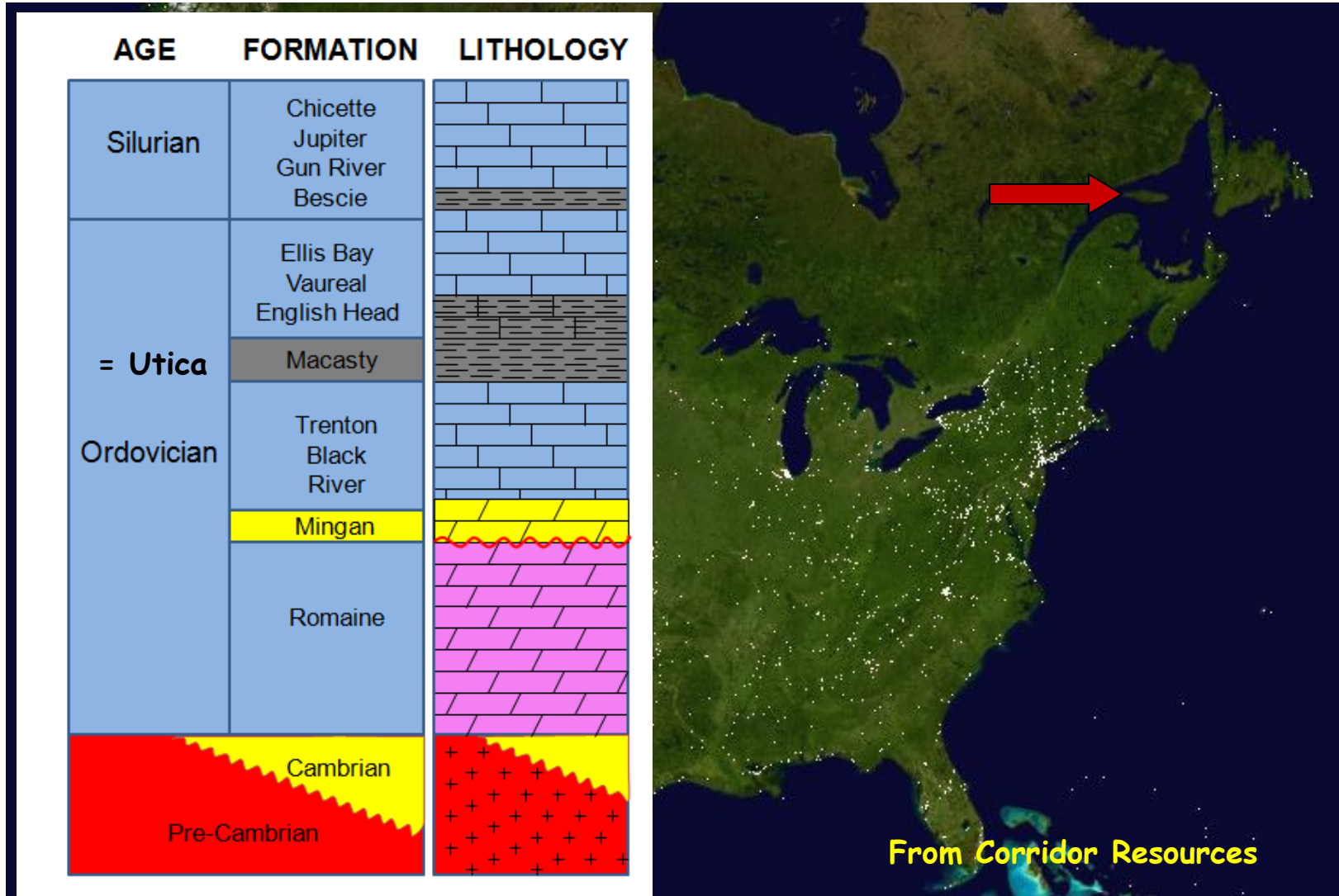


Cumulative distribution of estimated gas in place

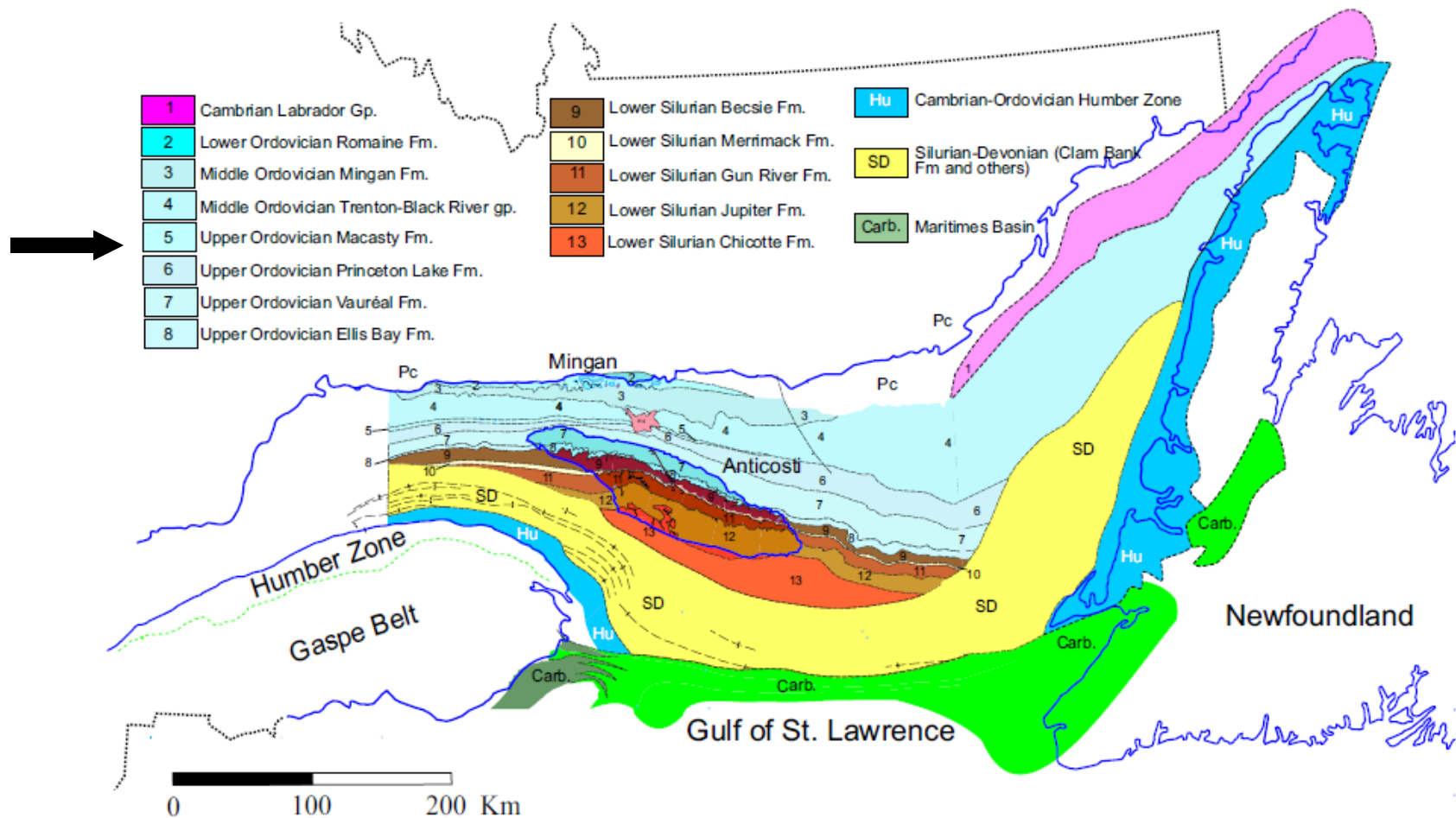
PRELIMINARY



A new potential target Shale oil in Upper Ordovician shales on Anticosti Island

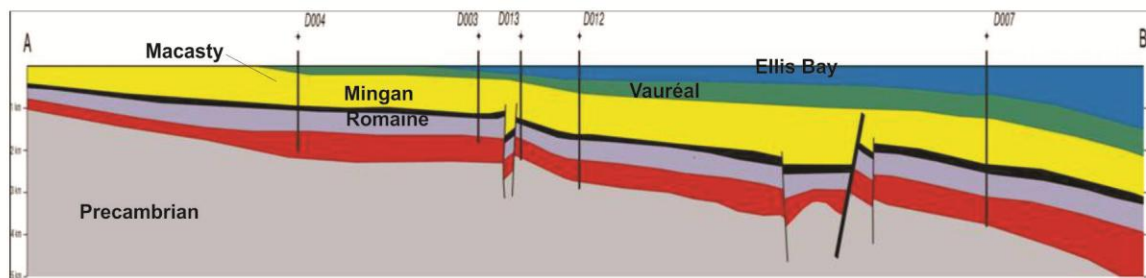
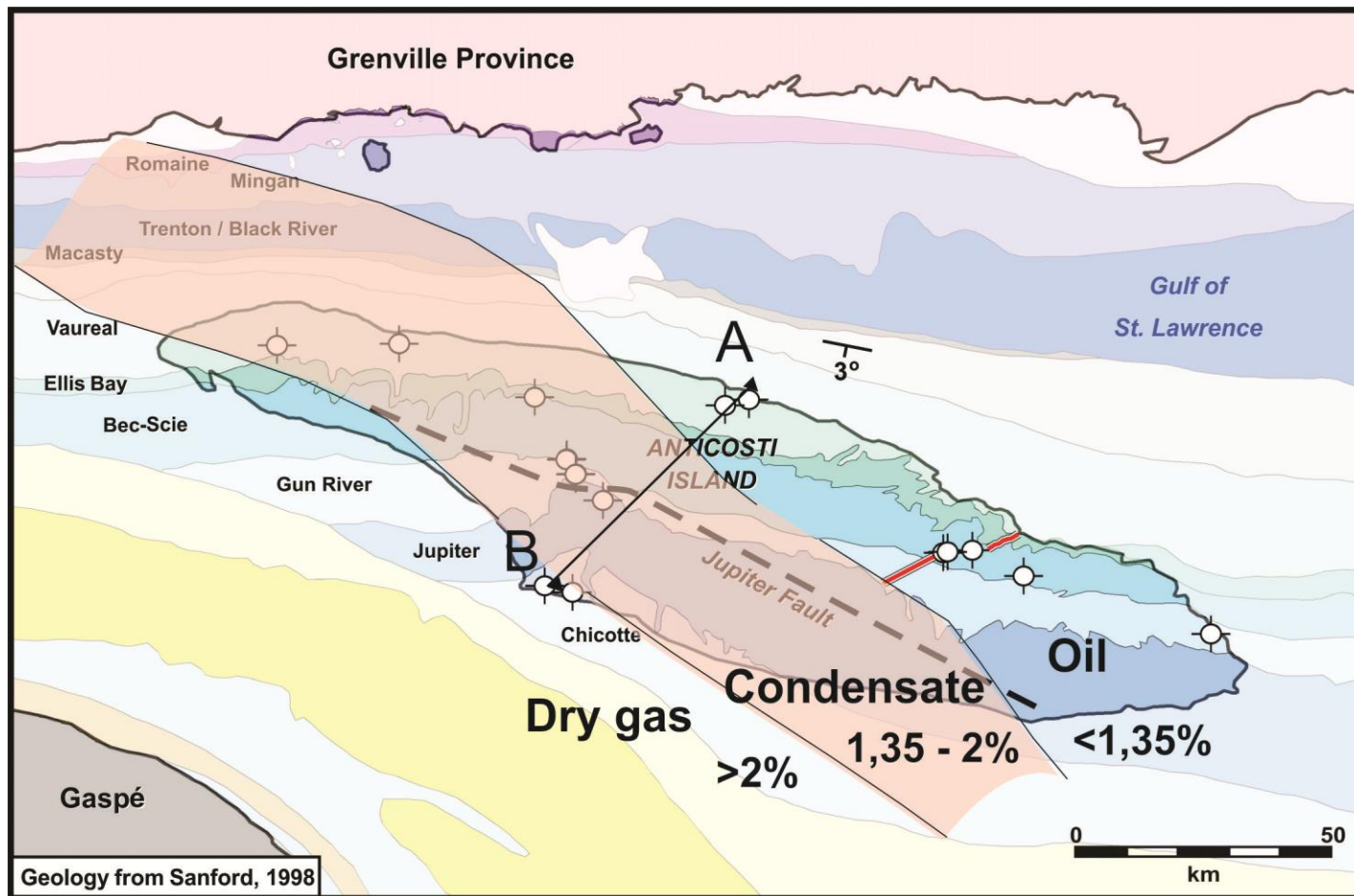


Geological setting of Lower Paleozoic rocks in eastern Quebec



Lavoie et al (2009, GSC Open File 6174)





(Lavoie et al., 2009)



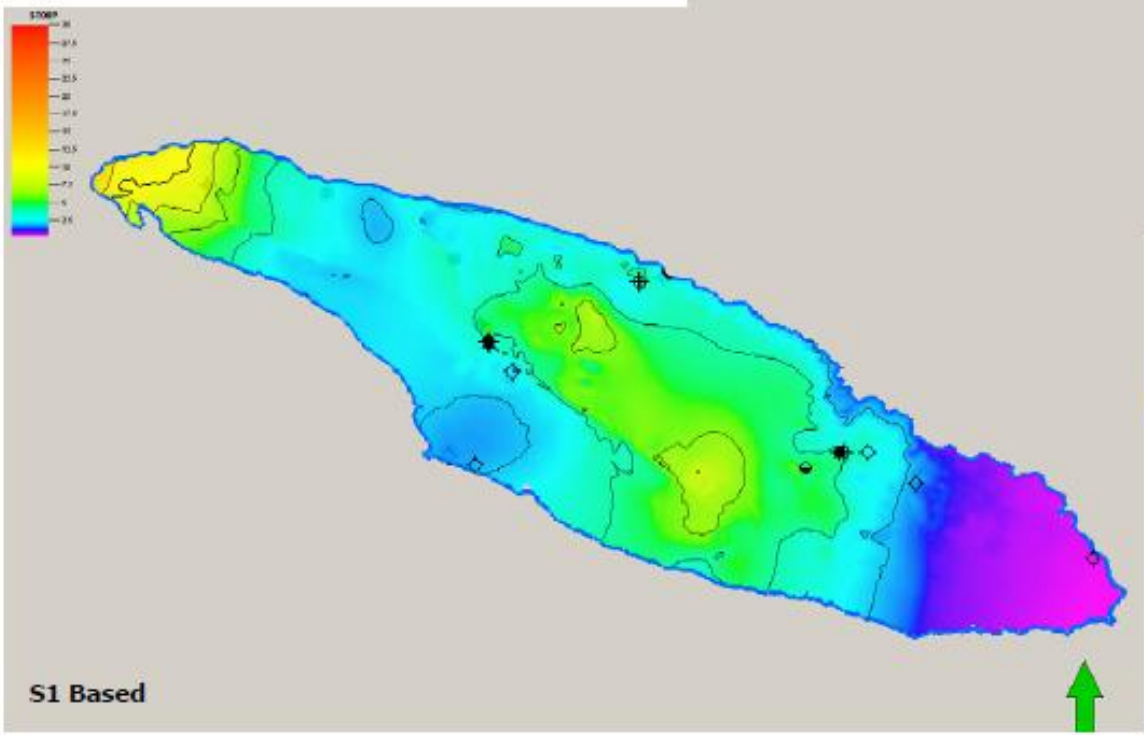
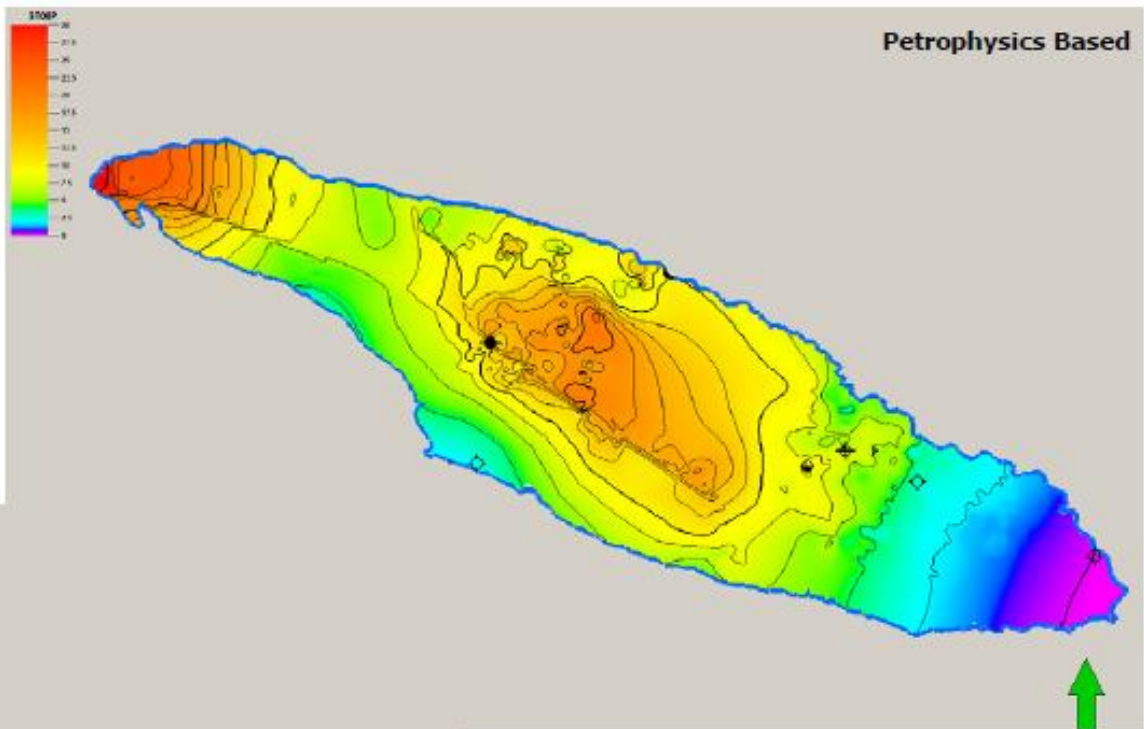
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Original Liquids In Place

P50: 60 BBL



Maps are displayed at the same value scale for both methodologies

(Petrolia, 2011)

AVAILABLE THERMAL INFORMATION AND HYDROCARBON INDICATORS BETWEEN QUEBEC CITY AND ANTICOSTI ISLAND



THERMAL MATURATION EASTERN QUEBEC

(Bertrand and Malo, 2010
GSC OF 6576)

Anticosti Island
400 km
to the NE

Next slide

Dry gas

Wet + dry gas








Dry gas

Oil window

Quebec
City

0 50km

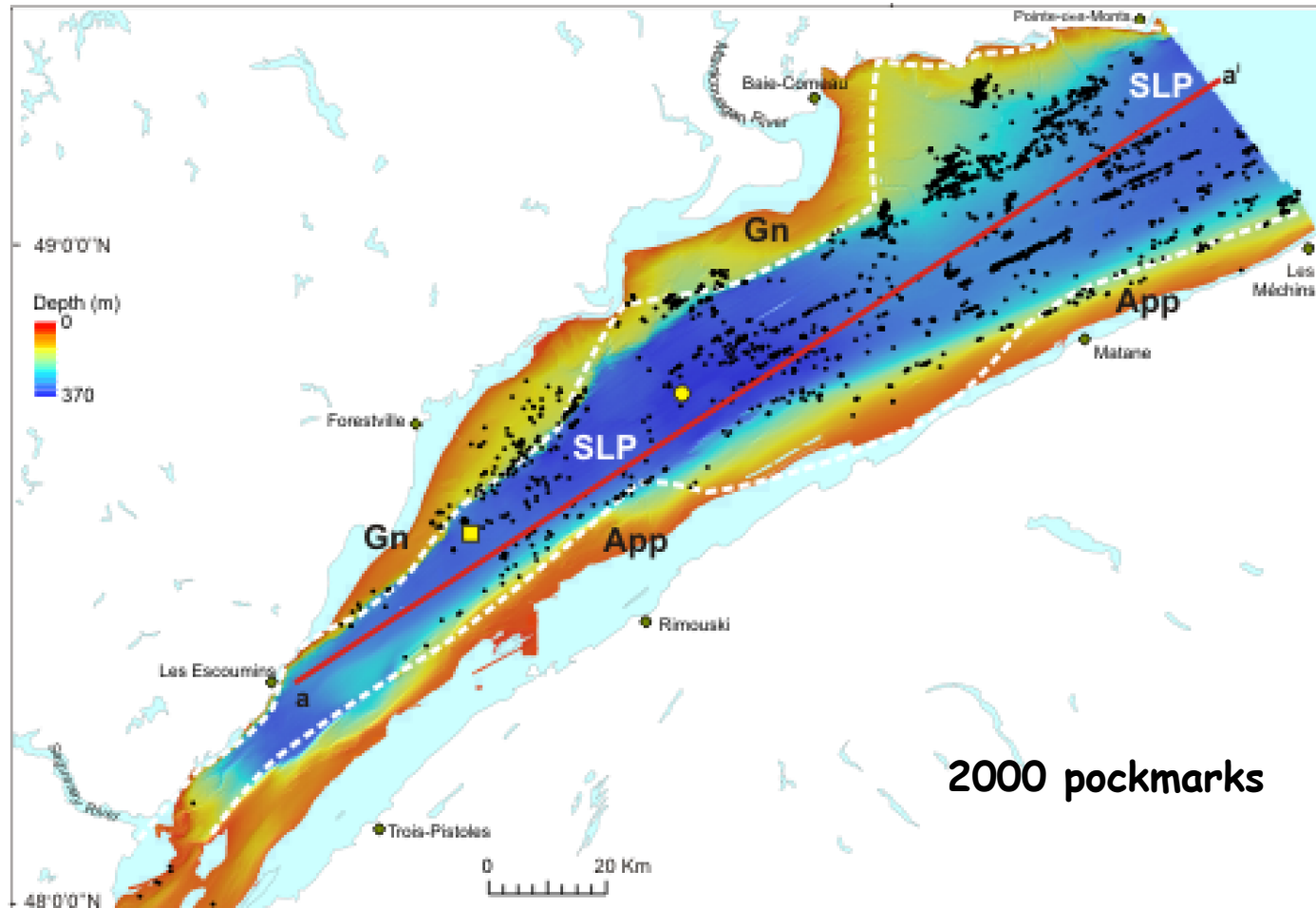
HYDROCARBON ZONES ORGANIC MATTER REFLECTANCE

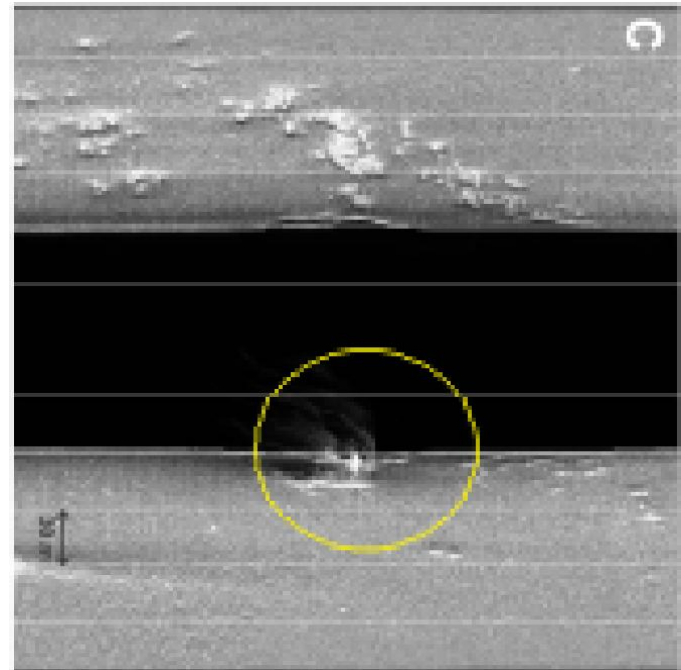
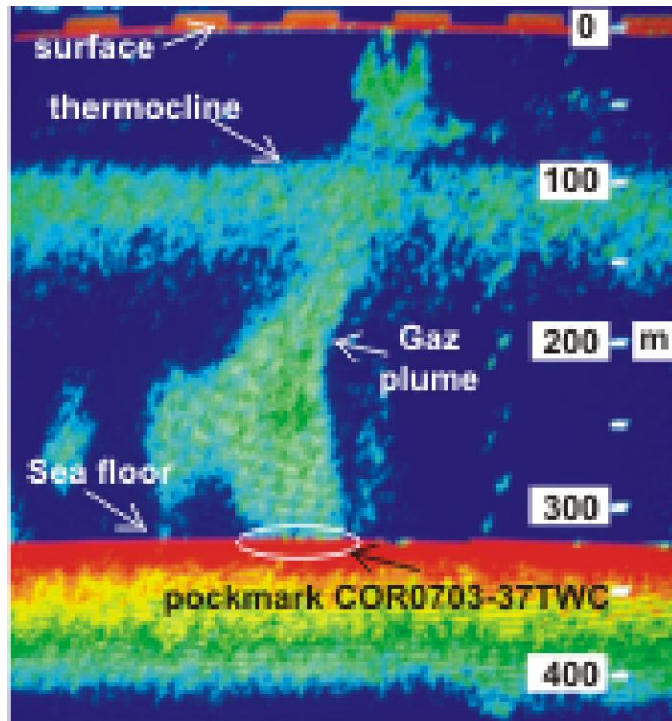
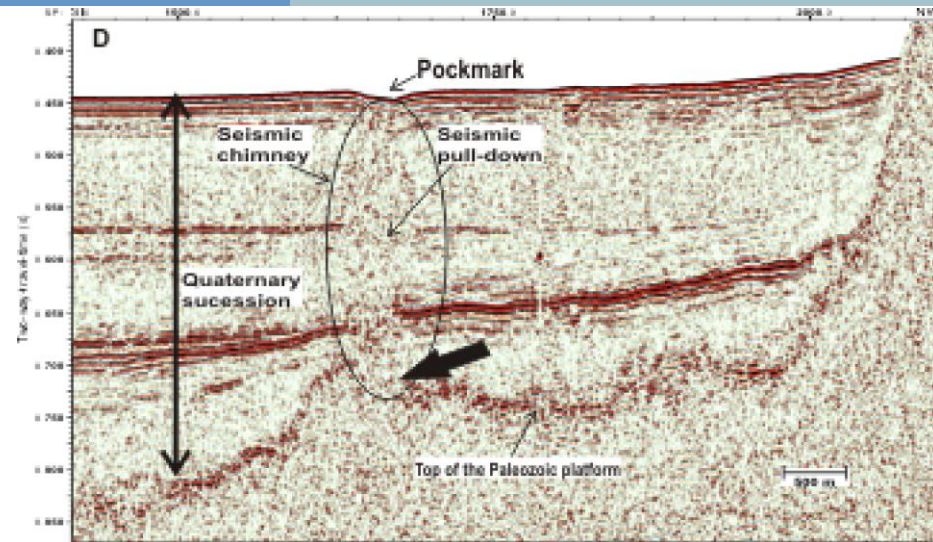
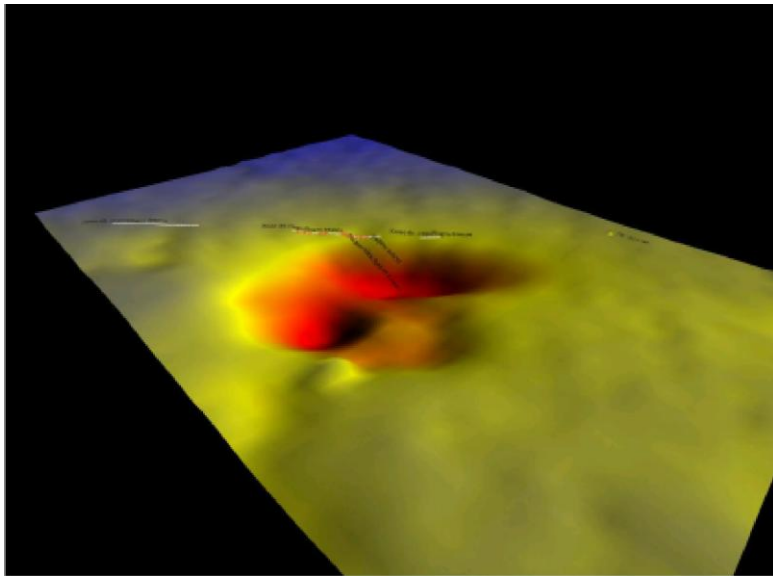
IMMATURE	$0,4 < R_{h-evi} < 0,6$	
OIL	$0,6 < R_{h-evi} < 1,0$	
	$1,0 < R_{h-evi} < 1,35$	
WET AND DRY GAS	$1,35 < R_{h-evi} < 2,0$	
DRY GAS	$2,0 < R_{h-evi} < 3,0$	
OVERMATURE	$3,0 < R_{h-evi} < 4,0$	
	$4,0 < R_{h-evi} < 6,0$	

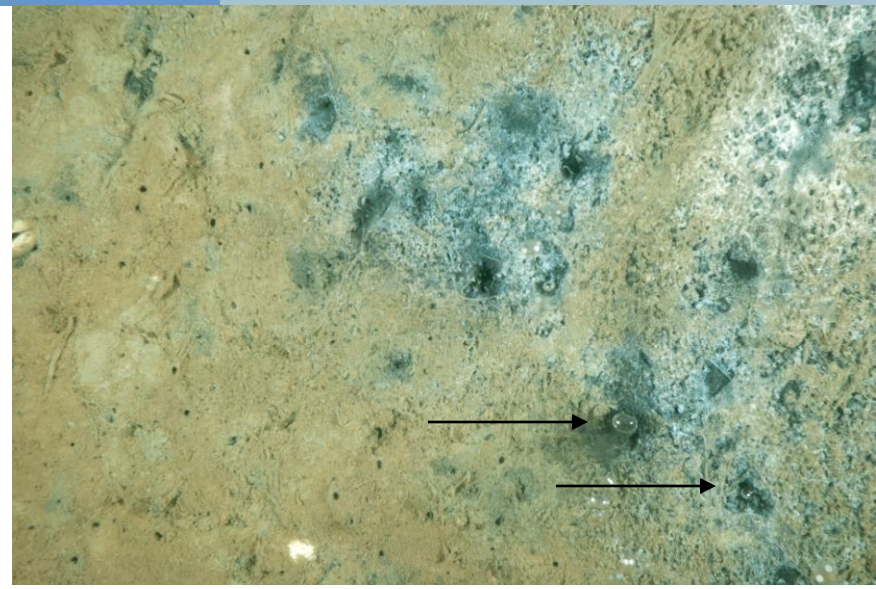


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The St. Lawrence Estuary between Quebec City and Anticosti Island - an estuary floor bottom riddled by pockmarks







**Active methane venting (bubbles)
from pockmarks with bacterial
mats and chemosynthetic carbonate
crusts**



Lavoie et al., (2010) *Marine and Petroleum Geology*



Conclusions

1. The Upper Ordovician black shales in Quebec consist of the Utica and Macasty calcareous shales.
2. The Utica Shale has been successfully fracked in southern Quebec with the best IP of 12 MMcf/d
3. Utica OGIP estimate based on logs is 135 Tcf (P50)
Utica OLIP estimate based on logs is 1.54 BBL (P50)
4. The Macasty has not been tested yet, preliminary technical data indicate that the shale is oil saturated and in the oil-wet gas windows
5. Preliminary OLIP (industry) estimates is 60 BBL (P50)



Thank you !

*Utica Shale along the Jacques Cartier River
30 km southwest of Quebec City*

