

The Upper Ordovician Utica and Lorraine Shales in Southern Quebec: A Regional Overview*

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Comments

A change from carbonates to various shales in eastern Canada occurred during Late Ordovician.

In Middle to Late Ordovician there was formation of a tectonic foreland basin.

Upper Ordovician black shales in eastern Canada include:

Billings (eastern Ontario)

Pointe Bleue (Lac St. Jean)

Utica (southern Quebec) (50-300 m thick)

Mccasty (Anticosti)

The Utica Shale represents a sedimentological response to sea level high and restricted oceanic circulation. Maturation increases from oil in northeast lowlands to dry gas southwest of it.

Since discovery in 2008, 30 Utica vertical - horizontal wells have been drilled, with some good frac results. However, after a wide environmental assessment and definition of best practices, a 24-30-month de facto moratorium with limited activities went into effect.

Selected References

Allen J.S., W.A. Thomas, and D. Lavoie, 2009, Stratigraphy and structure of the Laurentian rifted margin in the Northern Appalachians; a low-angle detachment rift system: *Geology*, v. 37/4, p. 335-338.

Bertrand, R., and V. Lavoie, 2006, Hydrocarbon source rocks and organic matter maturation of lower Paleozoic successions in the St. Lawrence

Platform and in the external domain of the Quebec Appalachians: GAC-MAC Annual Meeting, Montreal, Program with Abstracts.

Castonguay, S., J. Dietrich, D. Lavoie, and J.-Y. Laliberte, 2010, Structure and petroleum plays of the St. Lawrence Platform and Appalachians in Southern Quebec: insights from interpretation of MRNQ seismic reflection data: *Bulletin of Canadian Petroleum Geology*, v. 58, p. 219-234.

Lavoie, D., M. Obermajer, and M. Fowler, 2011, Rock-Eval/TOC Data from Cambrian-Ordovician of the Saint Lawrence Platform and Humber Zone, and Silurian-Devonian of the Gaspé Belt Successions, Quebec: Geological Survey of Canada, Open File 6050, 34 p., http://geopub.rncan.gc.ca/moreinfo_e.php?id=288027

Lavoie, D., and C. Guoxiang, 2010, An Ordovician “Lost City”; venting serpentinite and life oases on lapetus seafloor: *Canadian Journal of Earth Sciences*, v. 47/3, p. 199-207.

Miall, A.D., and R.C. Blakey, 2008, The Phanerozoic tectonic and sedimentary evolution of North America, *in* A.D. Miall (ed.) *The sedimentary basins of the United States and Canada*: Elsevier Amsterdam, Netherlands, v. 5, p. 1-29.

Ross, C.A., and J.R.P. Ross, 1988, Late Paleozoic transgressive-regressive deposition *in* C.K. Wilgus, B.S. Hastings, C.G. St. C. Kenall, H.W. Posamentier, C.A. Ross, and J.C. van Wagoner, (eds.), *Sea-level Changes-An Integrated Approach*: SEPM Special Publication, v. 42, p. 227-247.

Thomas, W.A., 1977, Evolution of Appalachian-Ouachita salient and recesses from reentrants and promontories in the continental margin: *American Journal of Science*, v. 277, p. 1233-1278.

Website

Blakey, 2011, Paleogeography: Website accessed 28 June 2011, <http://www2.nau.edu/rcb7/nam.html>



The Upper Ordovician Utica and Lorraine shales in southern Quebec:

A regional overview

Denis Lavoie
Geological Survey of Canada - Québec office





Cautionary statements (As requested by my employer)

The speaker is a carbonate sedimentologist / geochemist; has been dragged in shale gas in 2008 because he was the only GSC scientist with hydrocarbon experience in Quebec.

Do not expect high-flying shale science, he knows nothing on clastics

Avoid complex question on free vs absorbed gas, porosity in organic matter,
He simply does not know

The GSC cannot be held liable for any comments in this presentation

Outline

1. Introduction
2. Regional geological context of the Utica and Lorraine
3. Late Ordovician geological change: from carbonates to various shales in eastern Canada
4. Thermal maturation and organic geochemistry
5. Conclusions and a new Upper Ordovician shale play in Northern Ontario (?)





The current situation

April 1st, 2008 – Forest Oil announcement

Since, 30 Utica vertical – horizontal wells drilled

Some good frac results, fast learning curve

BUT: some « organized » public resistance

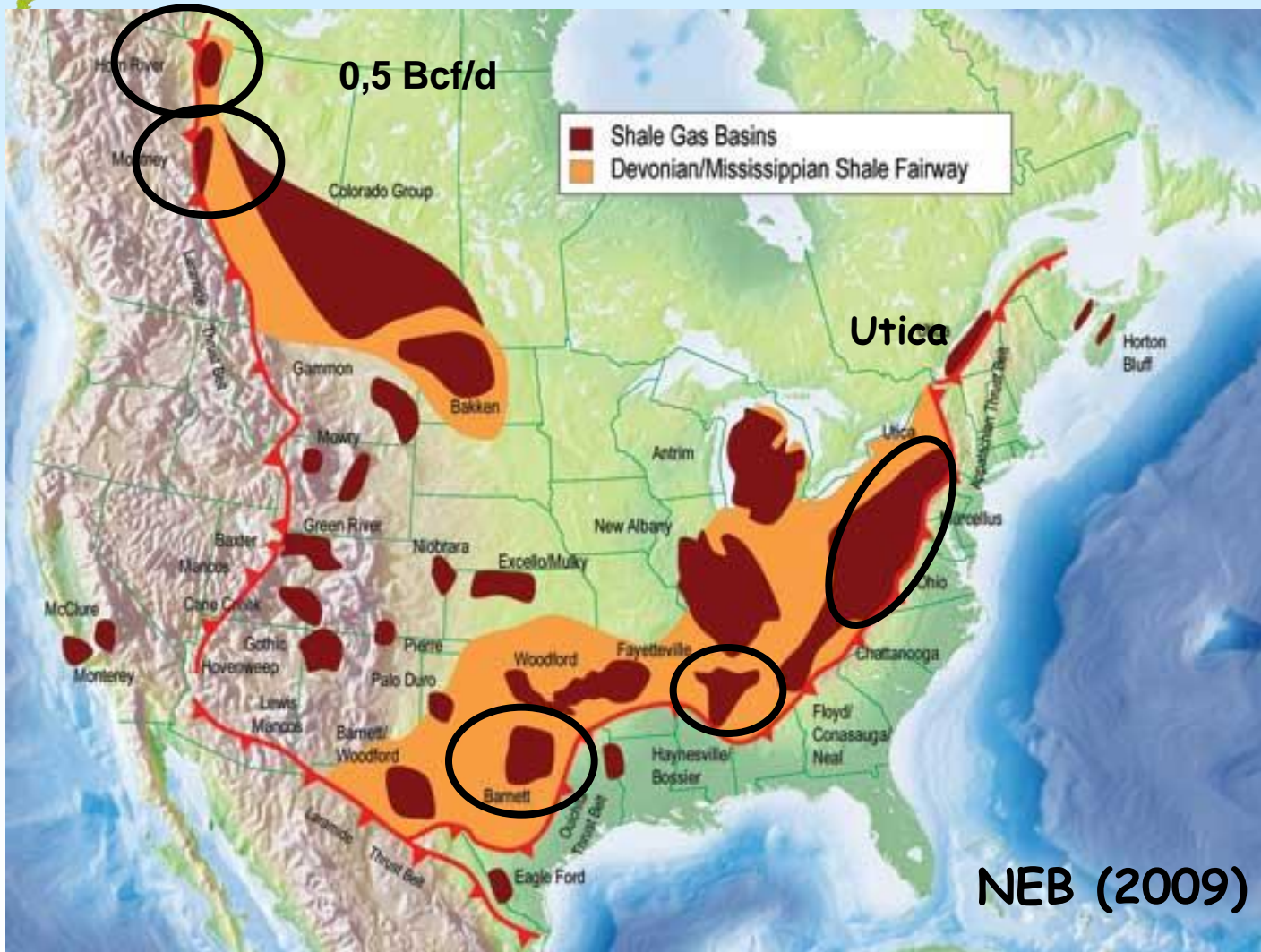
Quebec carried out public hearings in fall 2010

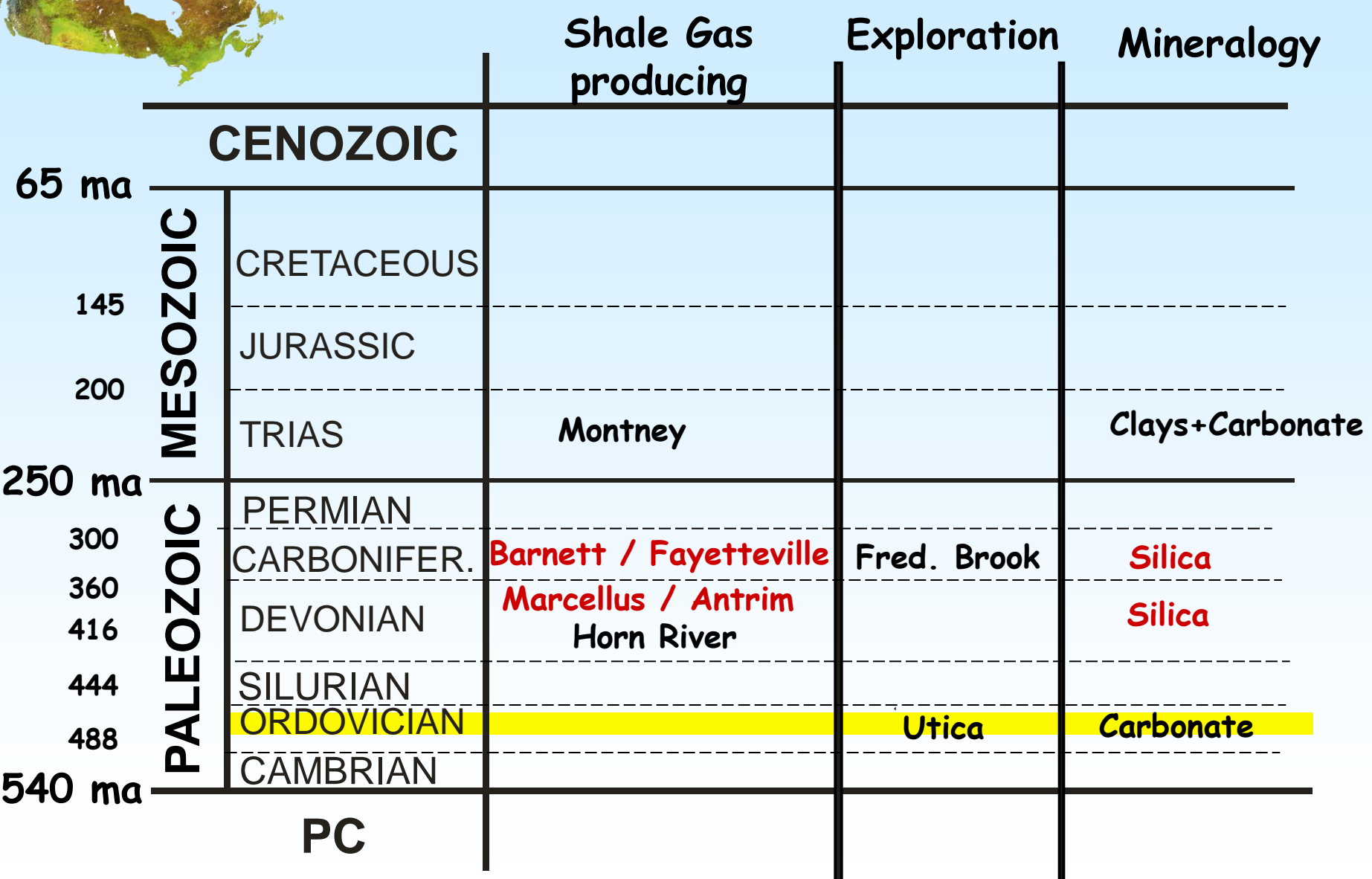
Conclusions: A wide environmental assessment and definition of best practices. A 24-30-month de facto moratorium with limited activities.



Shale gas in North America

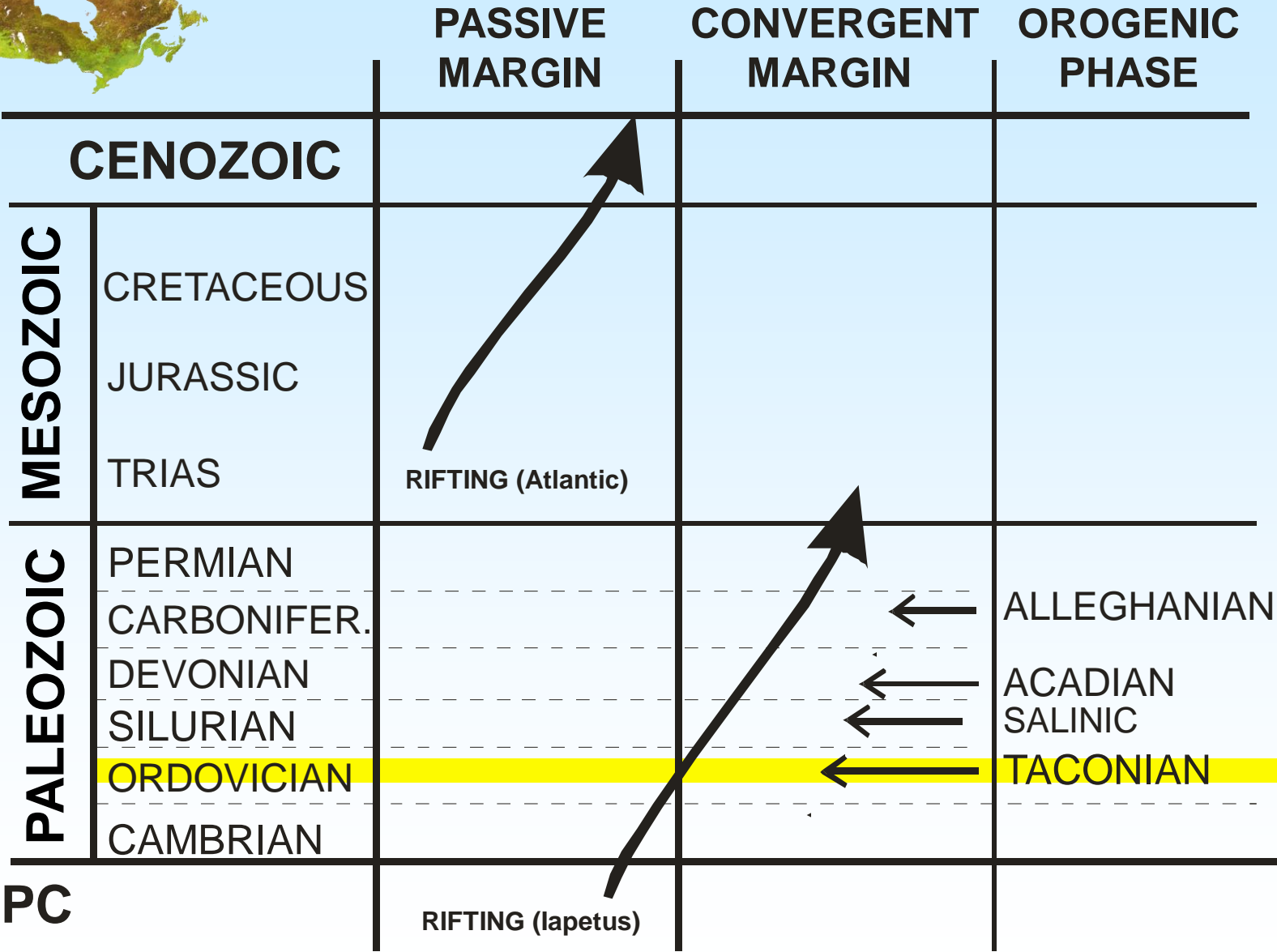
Abondant, diverse age and mineralogy







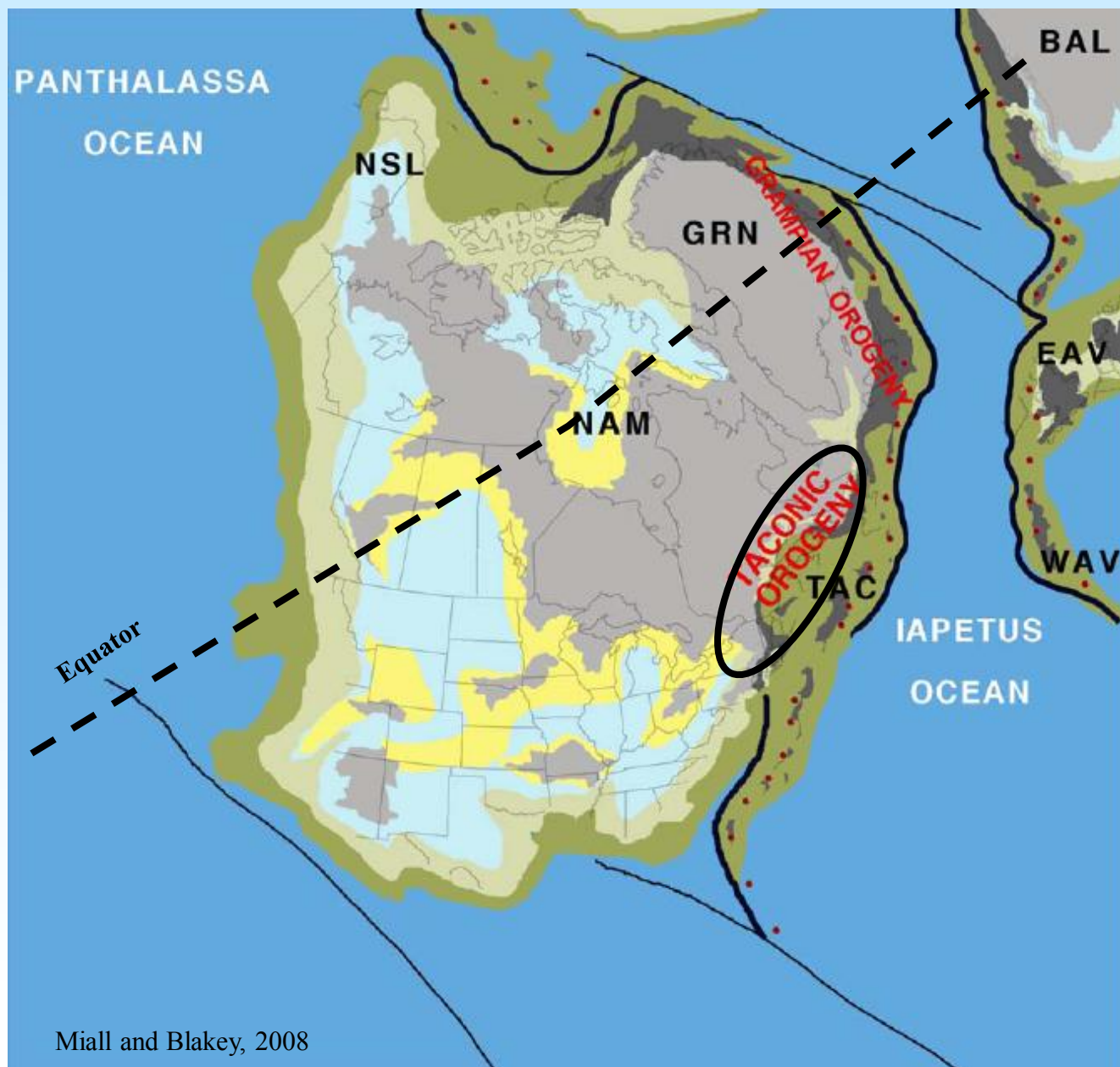
REGIONAL GEOLOGICAL CONTEXT





Mid to Late Ordovician

Formation of a tectonic foreland basin

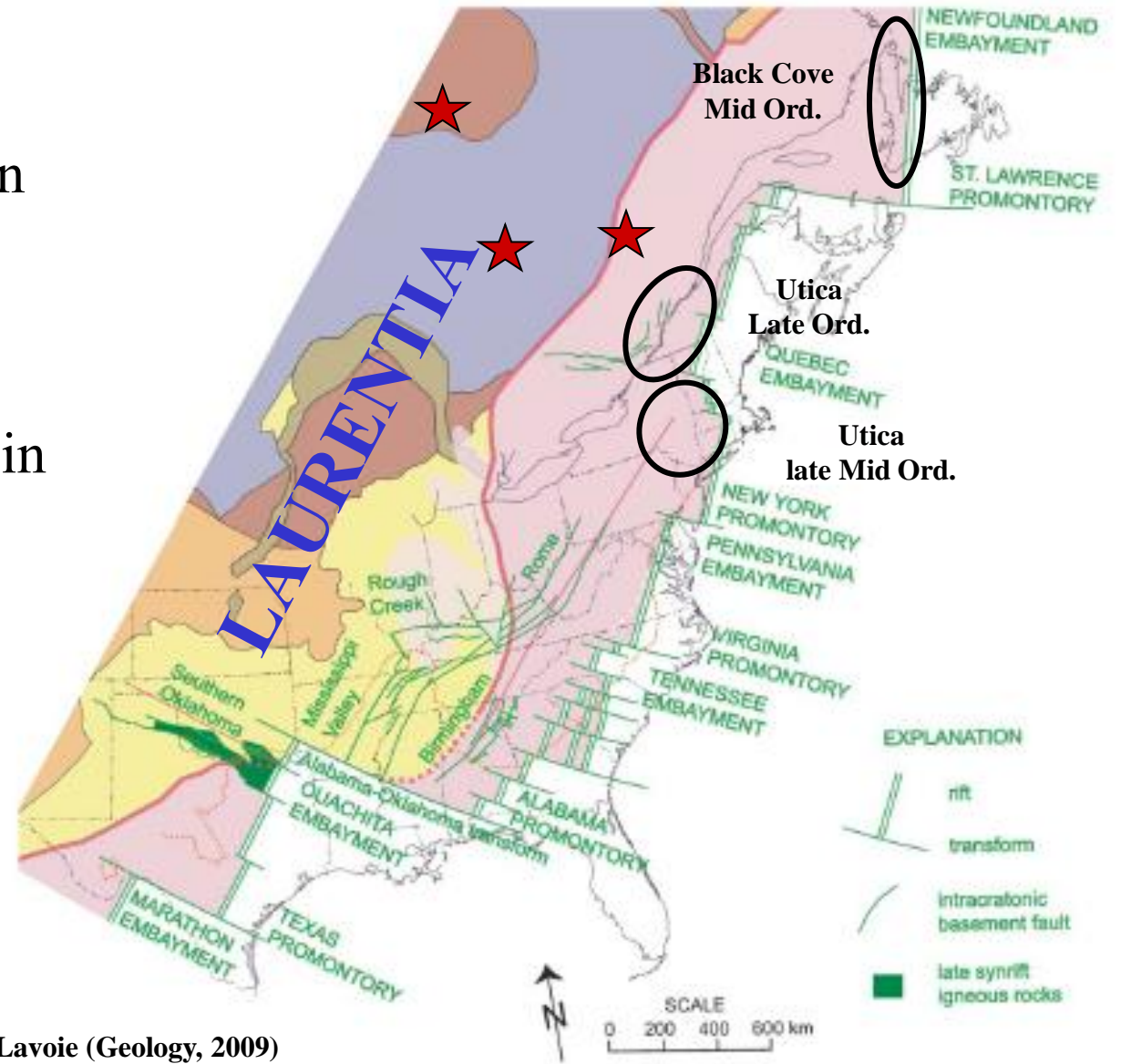




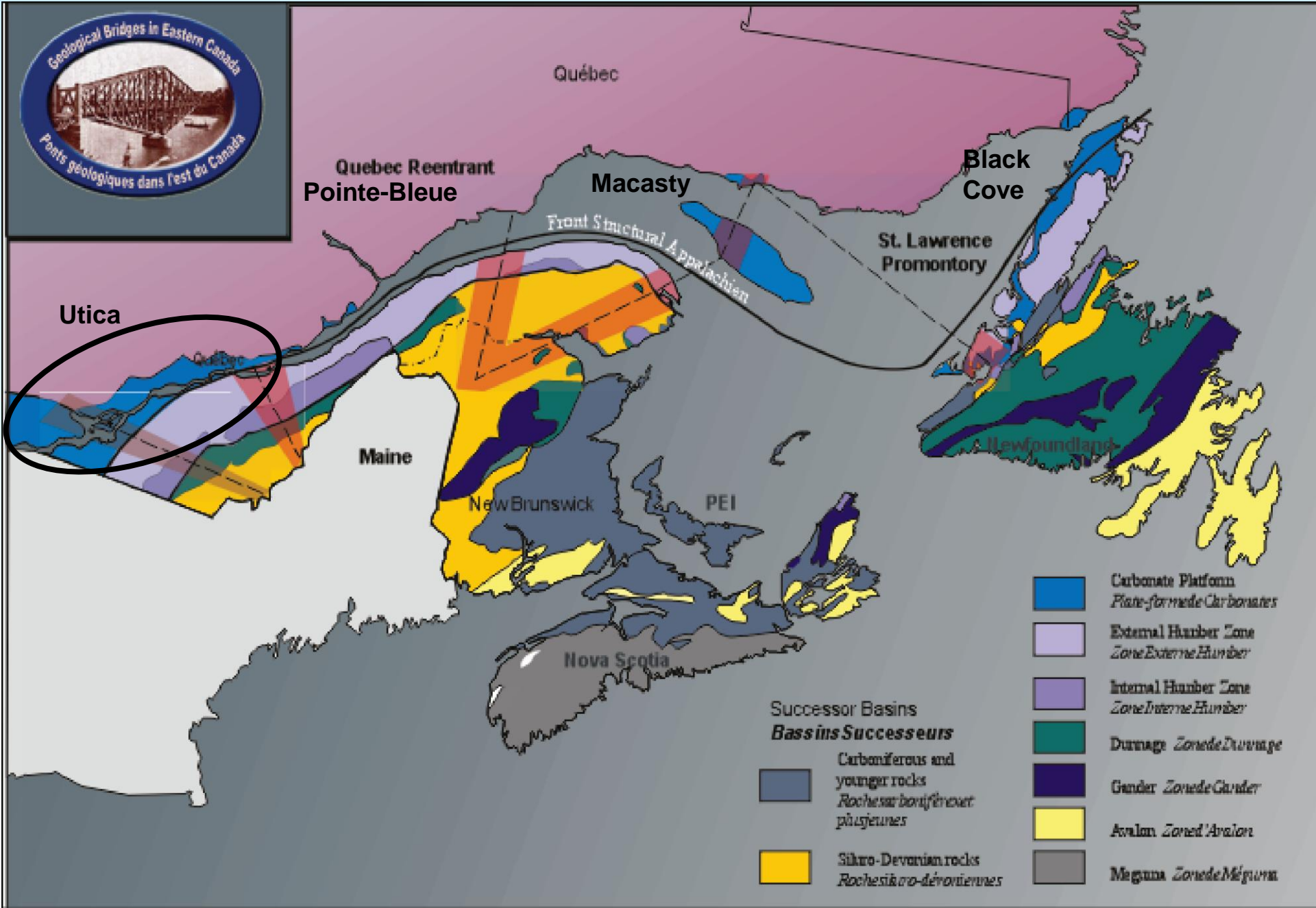
An Iapetan rifted margin of promontories and embayments

Control on foreland basin development and demise; onset of black shale sedimentation

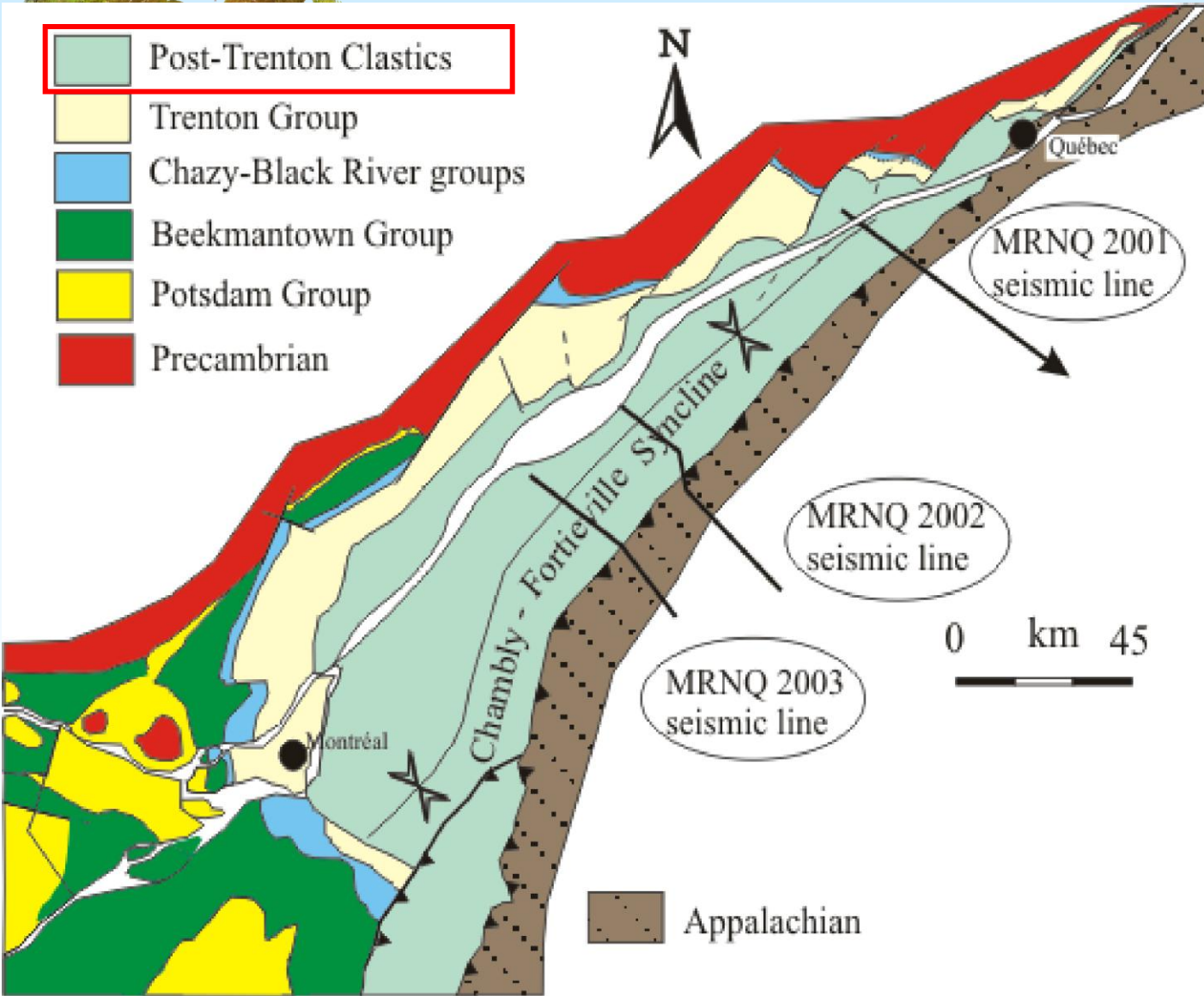
★ Other localities on the Pc Craton discussed later



Thomas (AJS, 1977); Allen, Thomas and Lavoie (Geology, 2009)



Upper Ordovician foreland clastics



Queenston Group			Convergent phase Foreland basin	
Lorraine Group	★	Fair reservoir potential		
Utica Group	★	Fair potential for gas source rock		
Trenton Group		Good reservoir potential		
Black River Gr		Good reservoir potential		
Chazy Gr				
Ordovician				
Beekmantown Group	Carillon		Rifting and drifting (divergent) phases Passive margin	
	Beauharnois	Good reservoir potential		
	Theresa	Fair reservoir potential		
Cambrian	Potsdam Group	Cairnside		Fair reservoir potential
		Covy Hill		
Precambrian	Grenville			

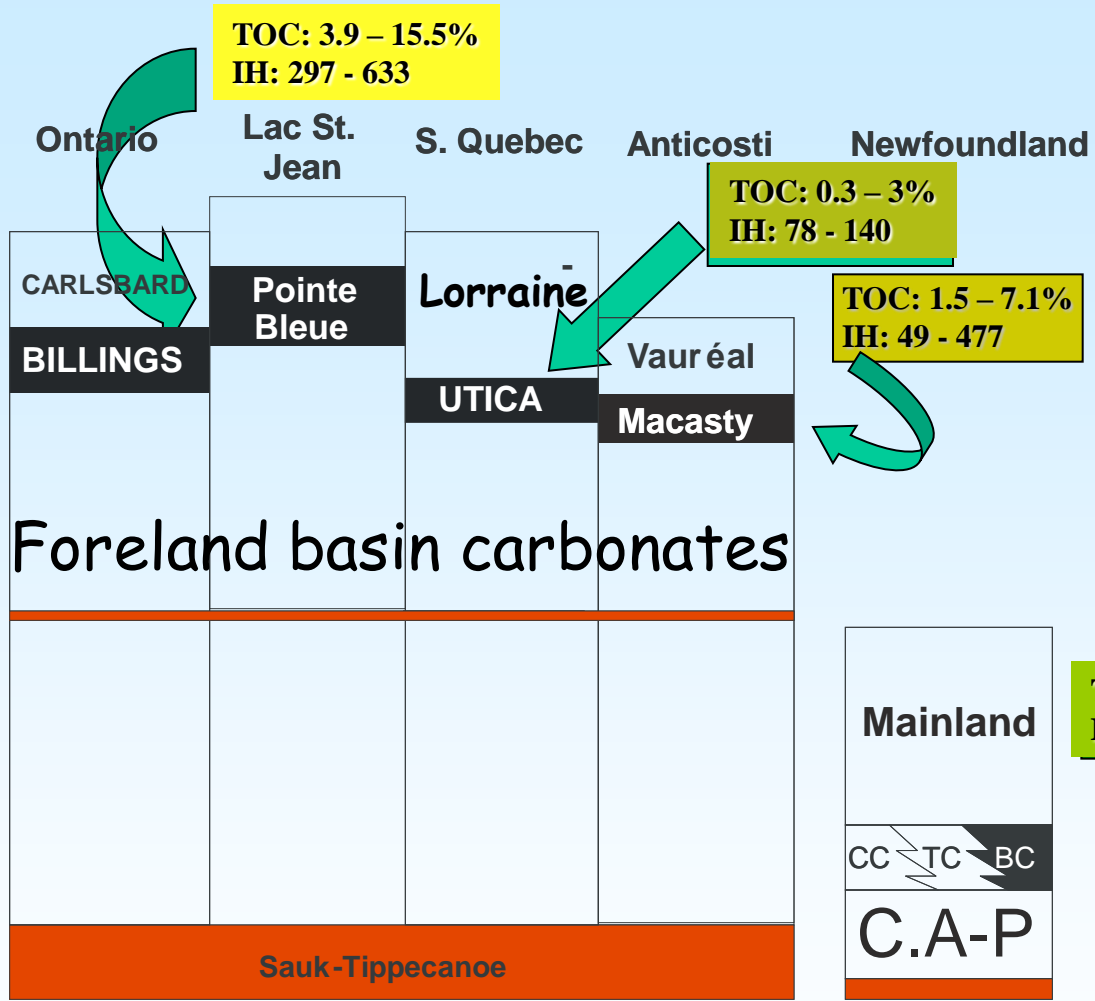


Ordovician black shales in eastern Canada



SILURIAN

ORDOVICIAN	UPPER	Ashgill.
		Caradocian
	MID	Darriwilian
LOWER	Arenig	

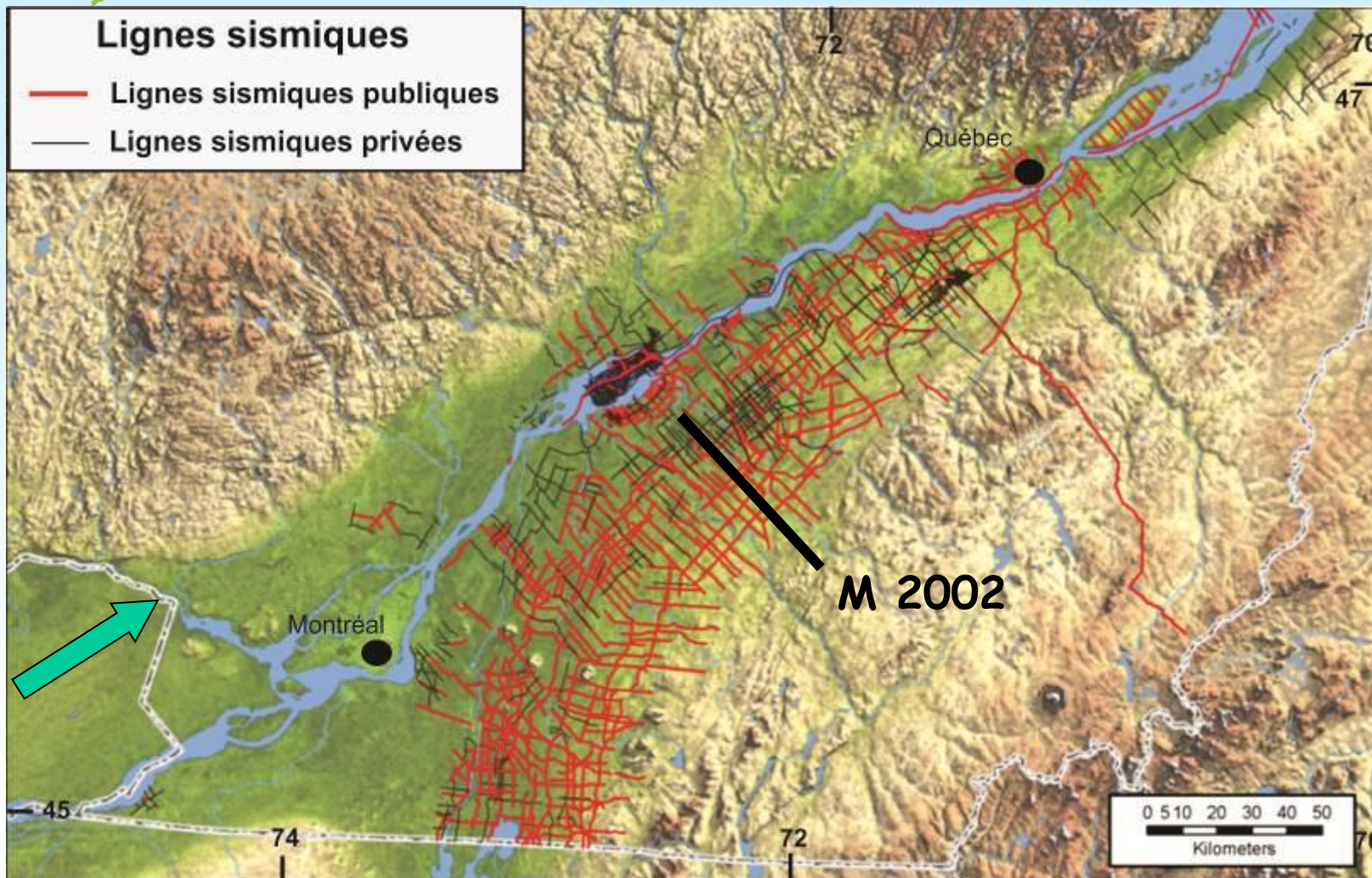


Natural Resources Canada

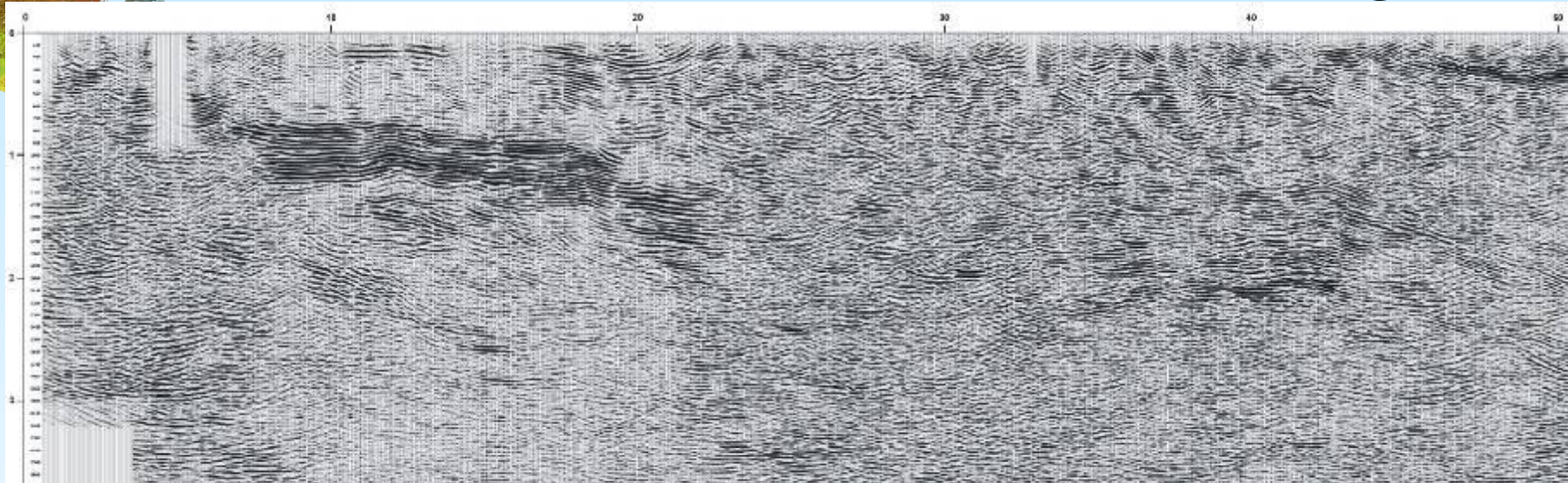
Ressources naturelles Canada



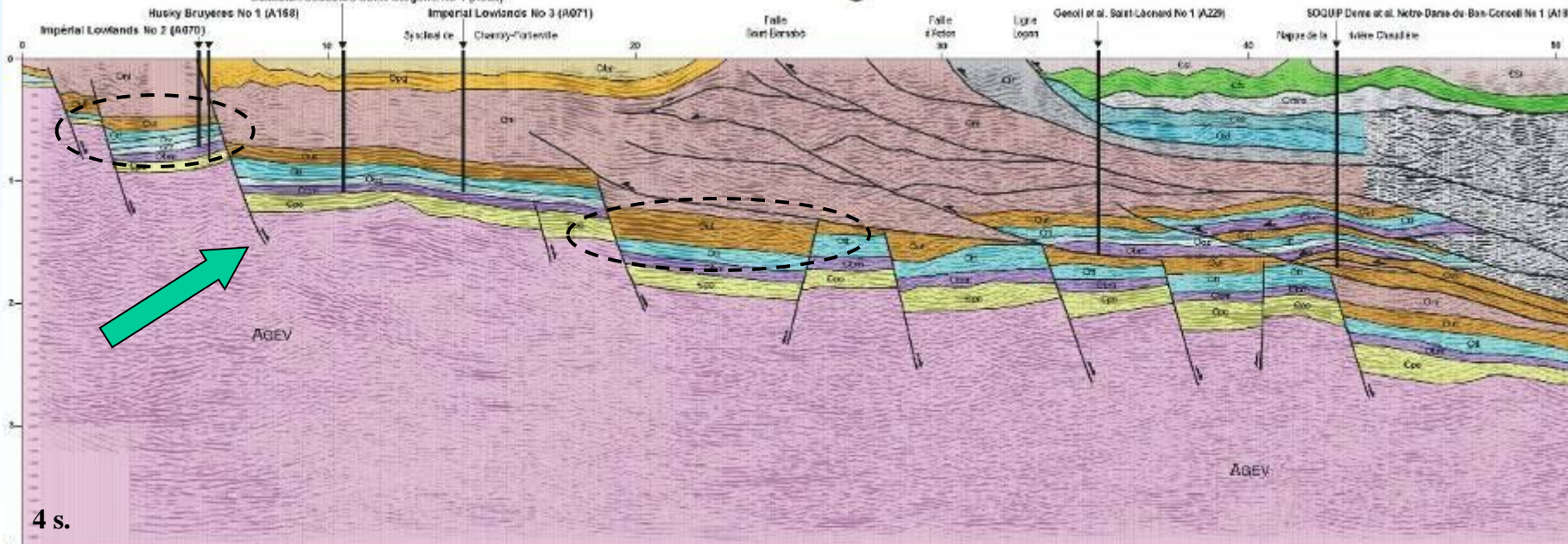
Seismic reflection and subsurface understanding



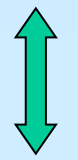
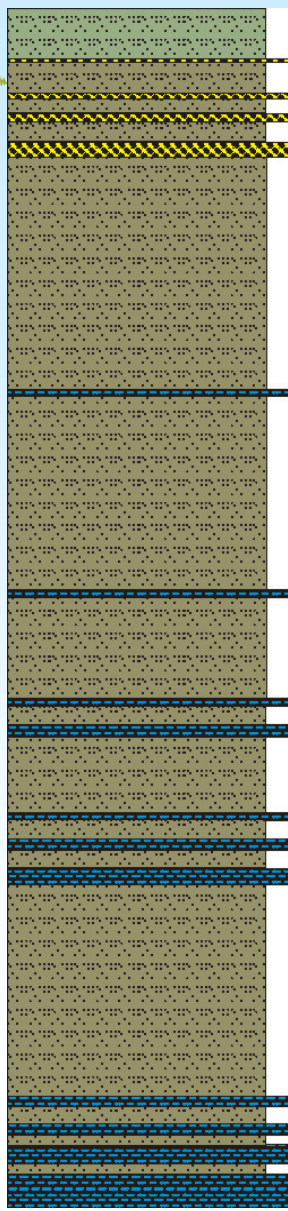
Seismic reflection and subsurface understanding



M-2002: Time migrated



4 s.

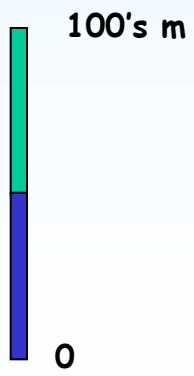


Lorraine (> 1000 m)

Utica (50 - 300 m)



Trenton (250 - 300 m)

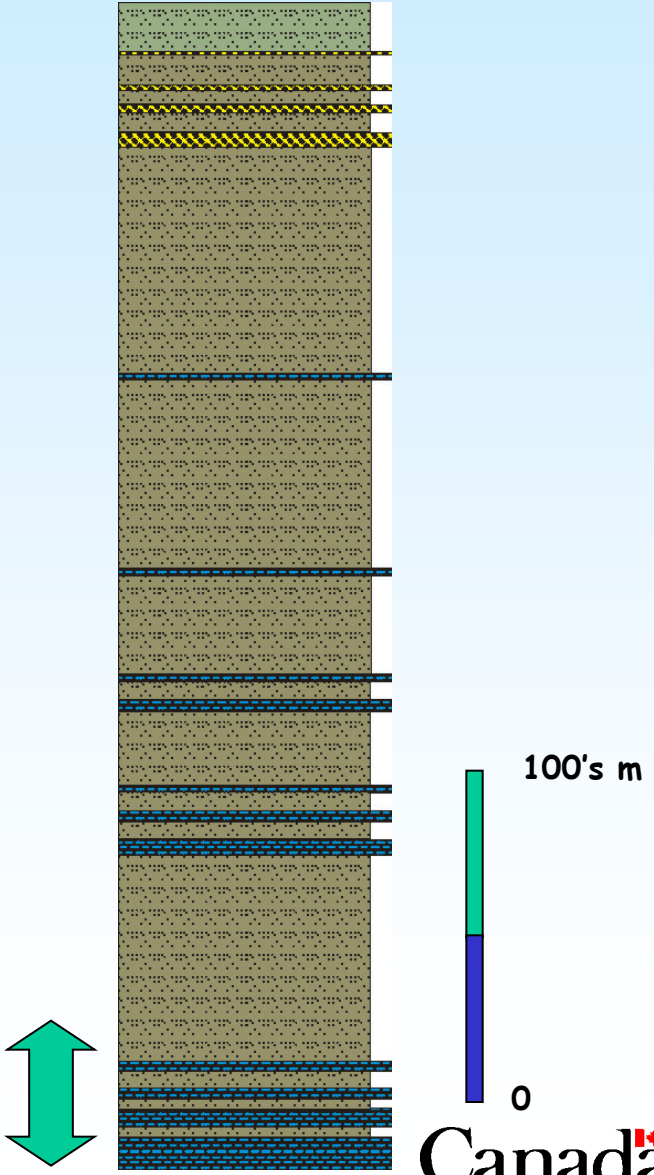
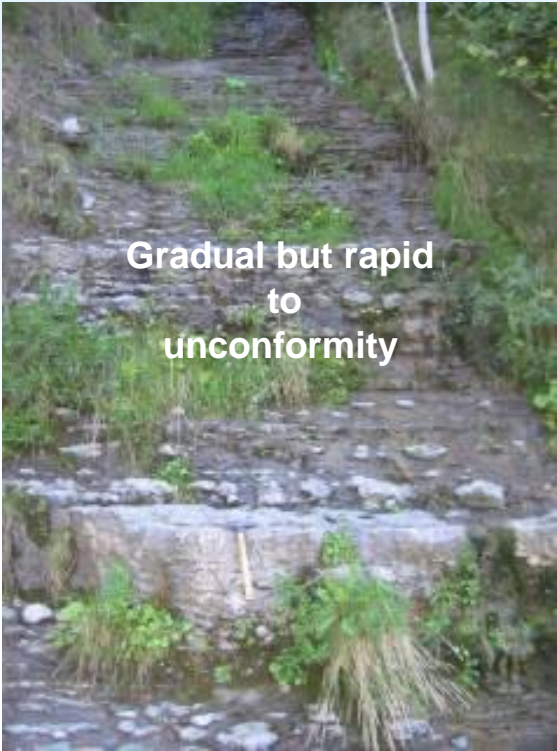


Natural Resources Canada

Ressources naturelles Canada

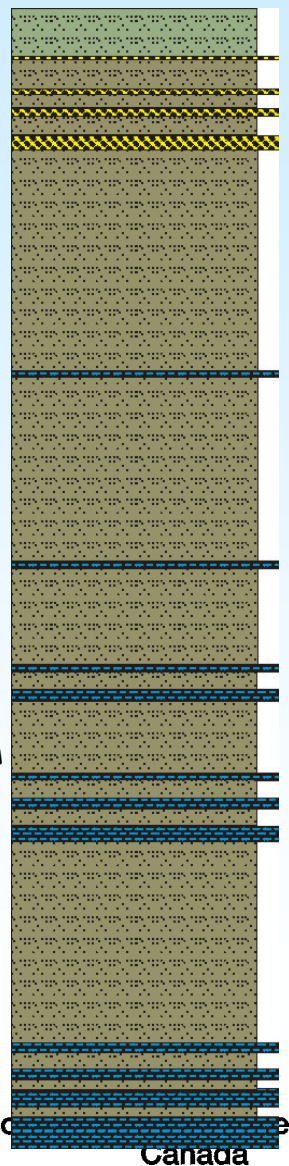
Canada

The Trenton – Utica transition





The Utica



100's m
0

Natural Resources Canada / Ressources naturelles Canada

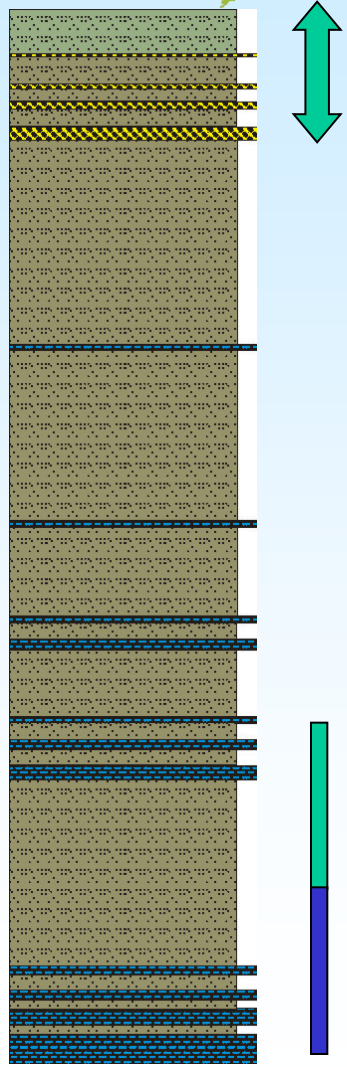


Burrows
Ostracodes, Cephalopods,
Trilobites, Chitinozoans,
Little to NO pyrite

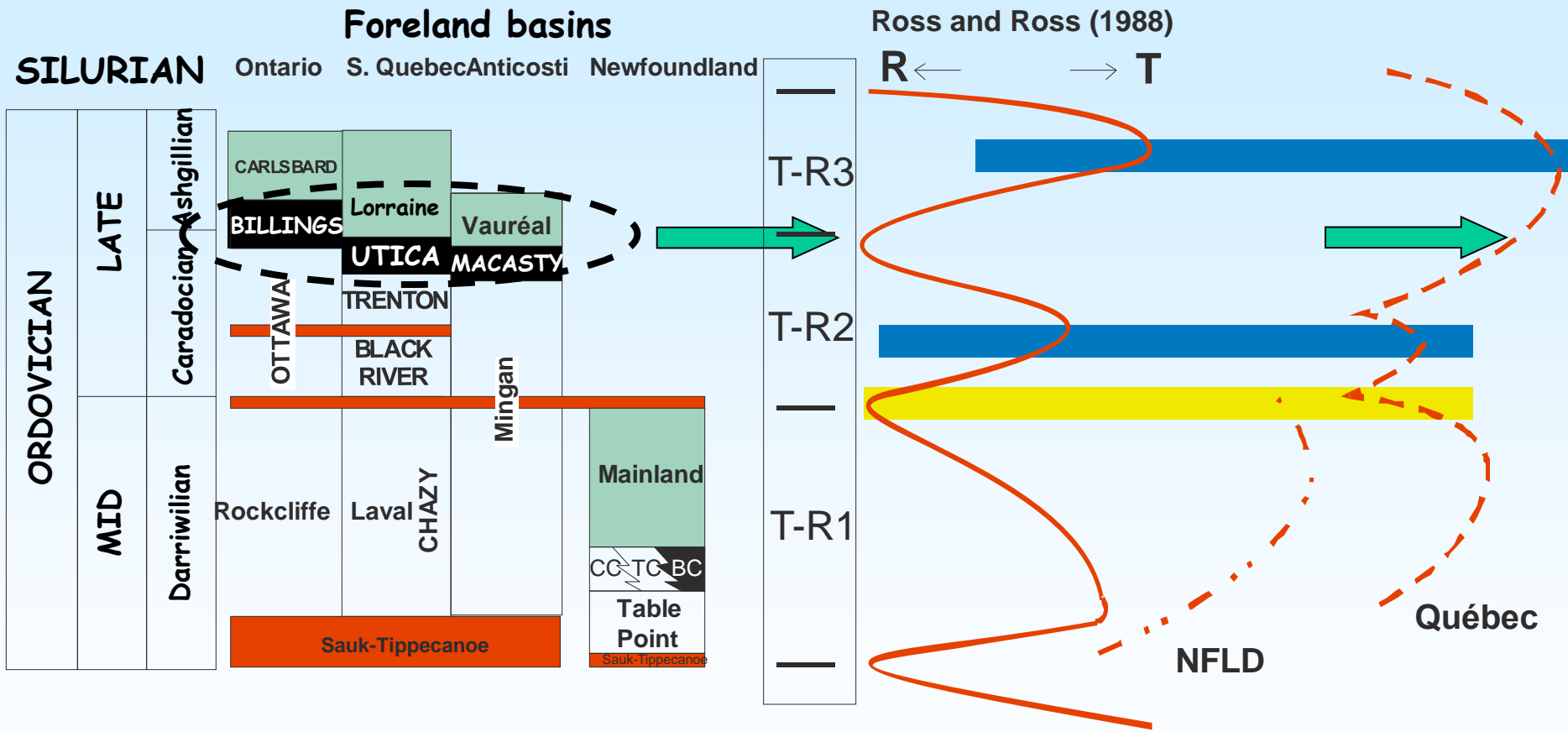


Cyclic micrite beds

The Utica-Lorraine flysch transition



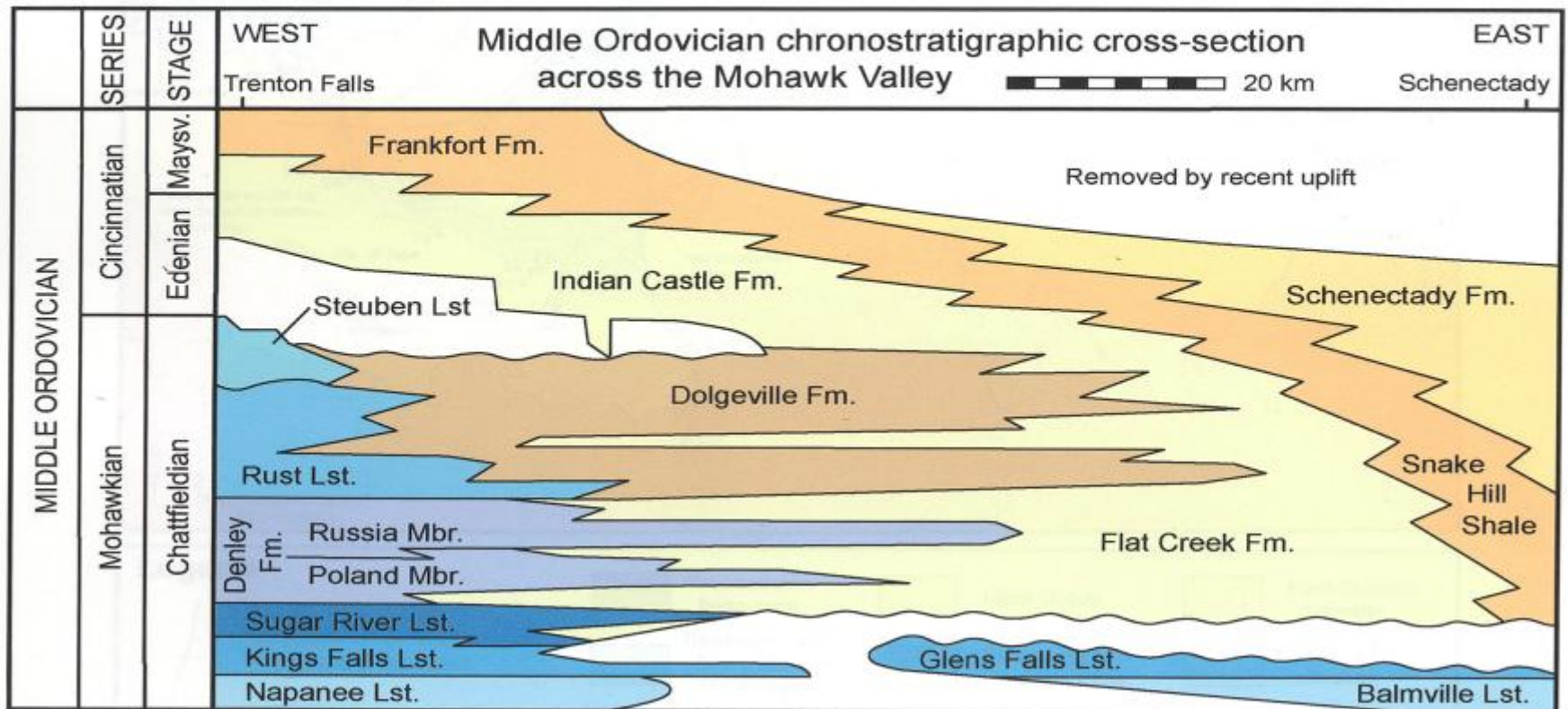
A major tectonic control



Stratigraphic framework - Trenton / Utica New York

(How many times now?)

Figure 8.



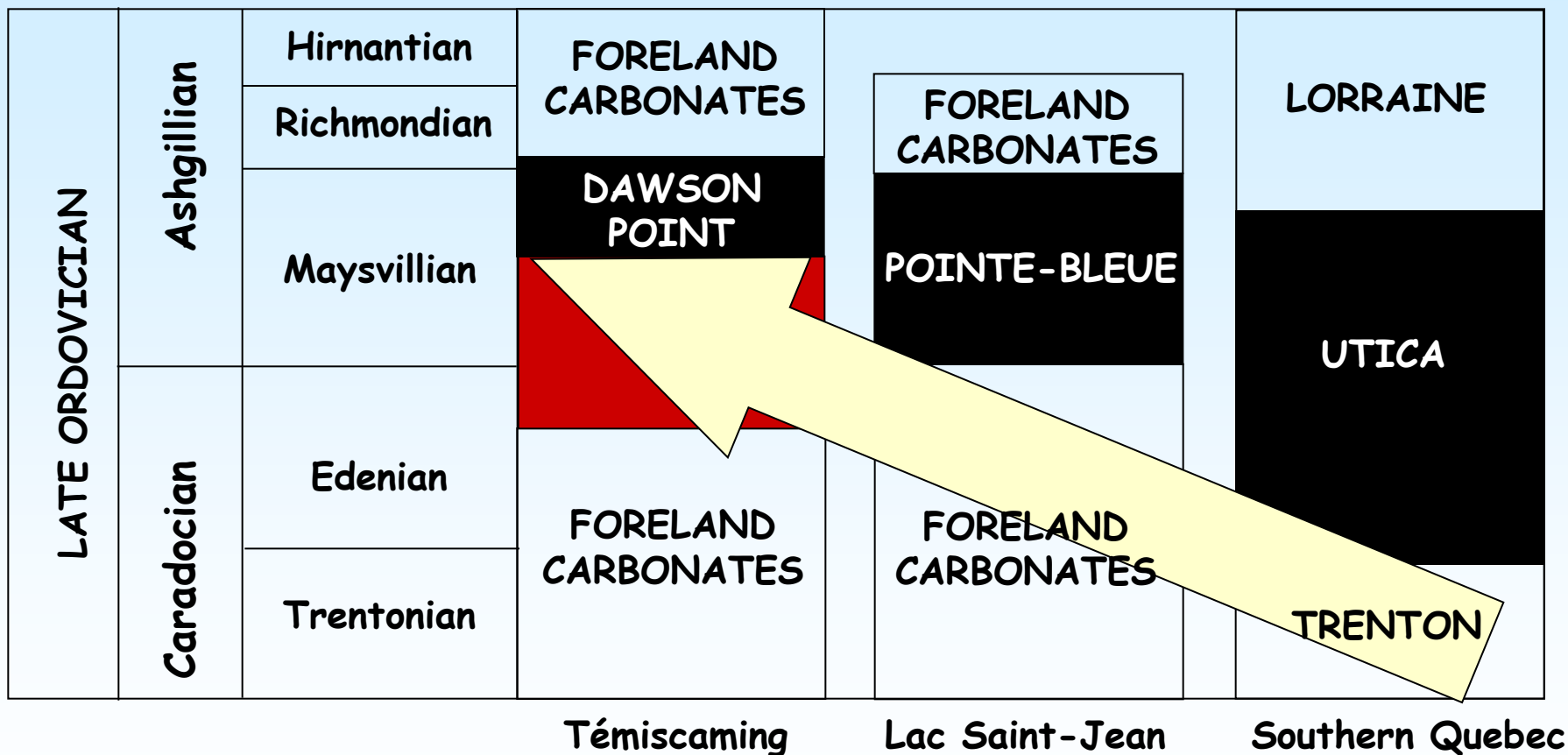
FIGURES 8-11-12-13-14

Stratigraphic framework Upper Ordovician Limestones vs clastics

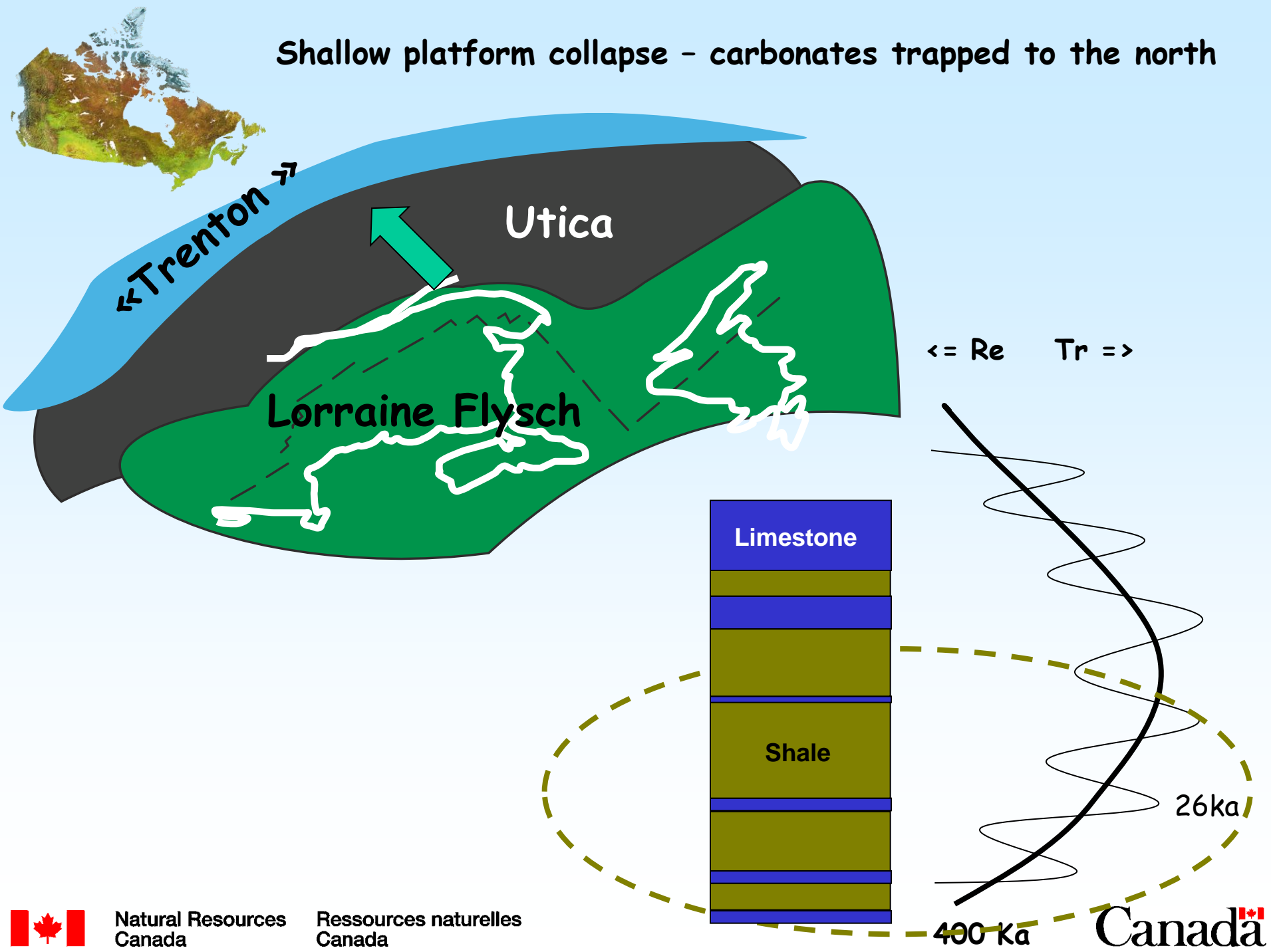


NW

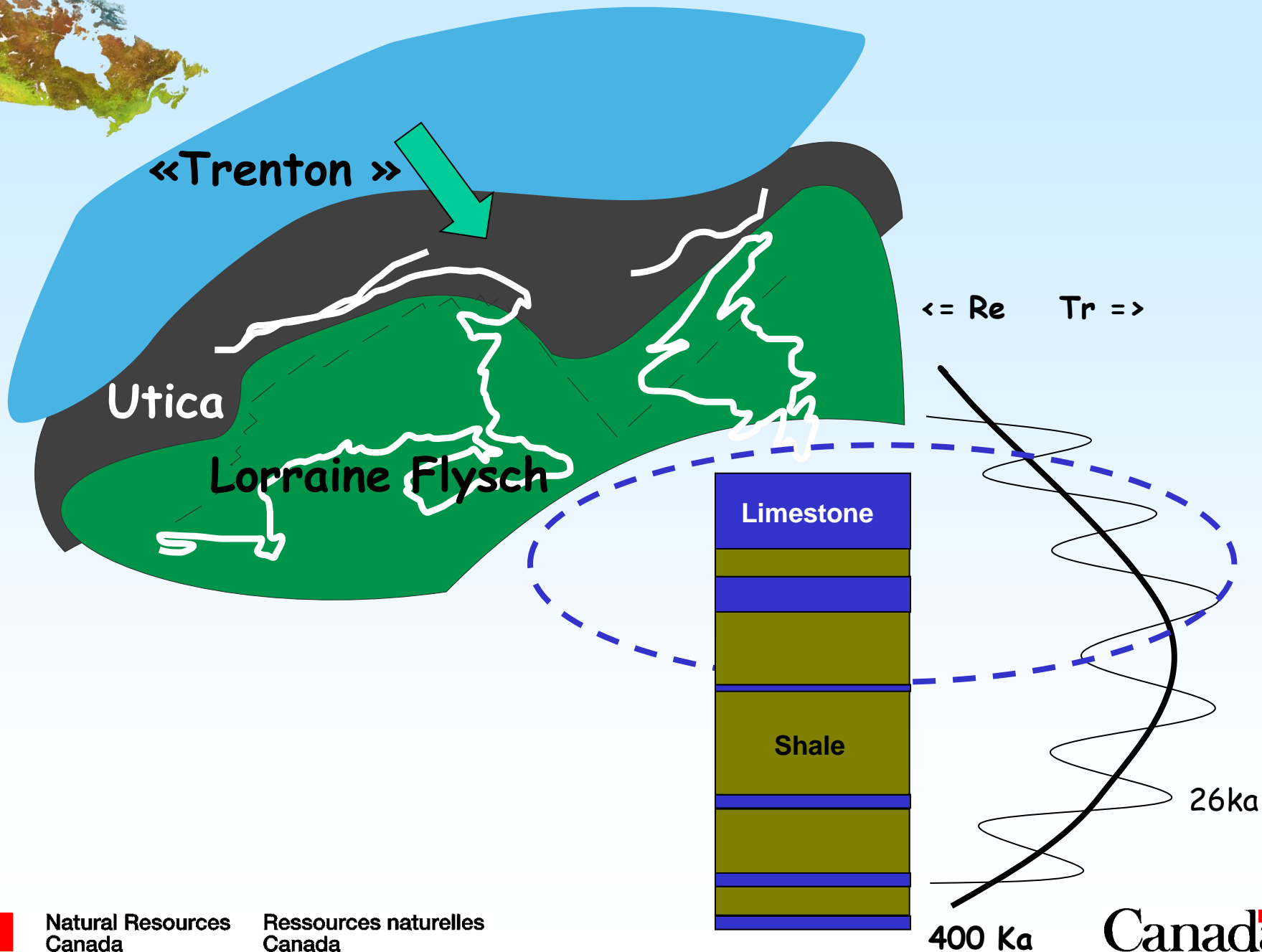
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Shallow platform collapse - carbonates trapped to the north



A Late Ordovician carbonate platform on the craton





The Upper Ordovician Utica Shale

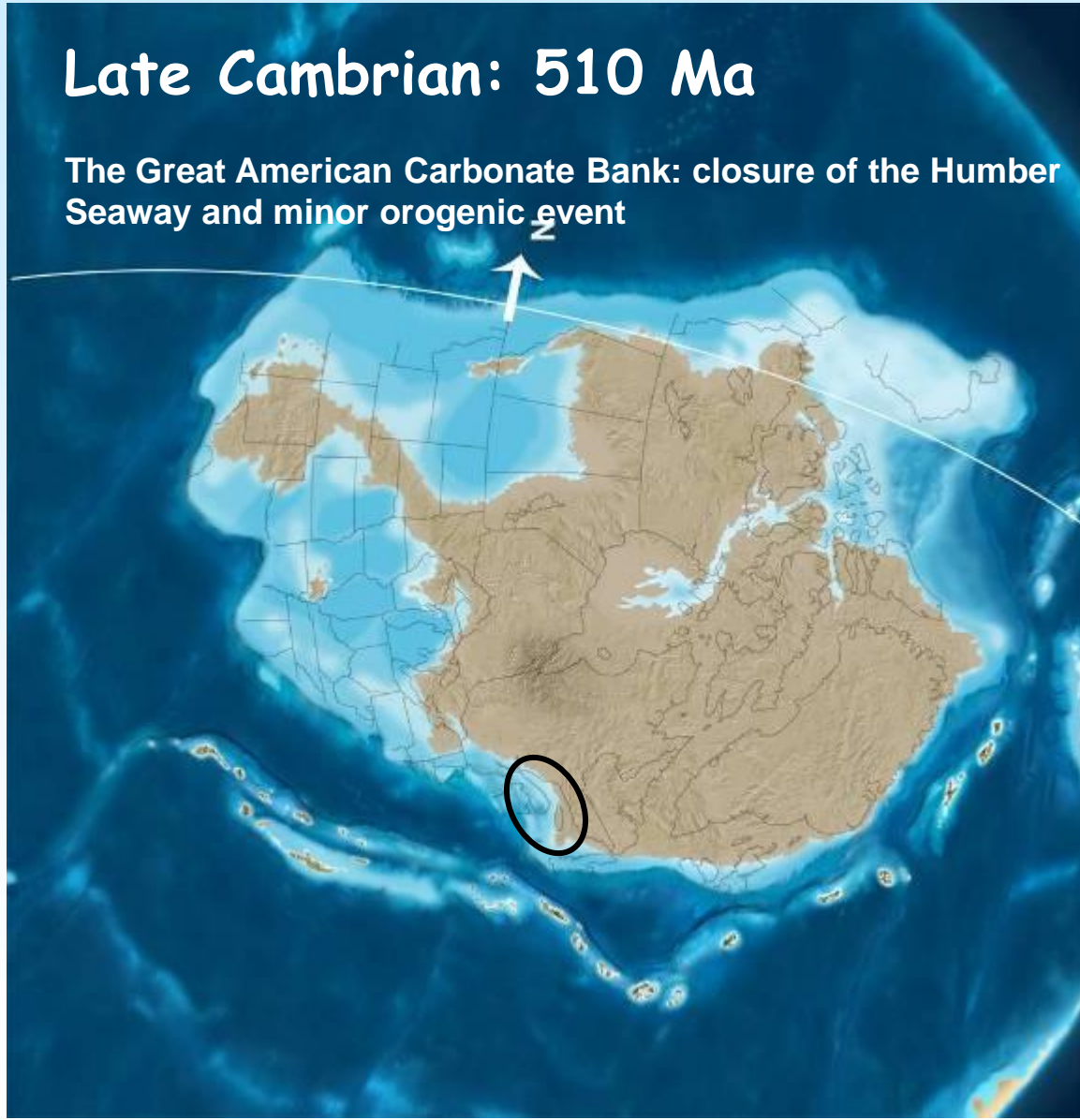
Sedimentological response to sea level high and restricted oceanic circulation





Late Cambrian: 510 Ma

The Great American Carbonate Bank: closure of the Humber Seaway and minor orogenic event

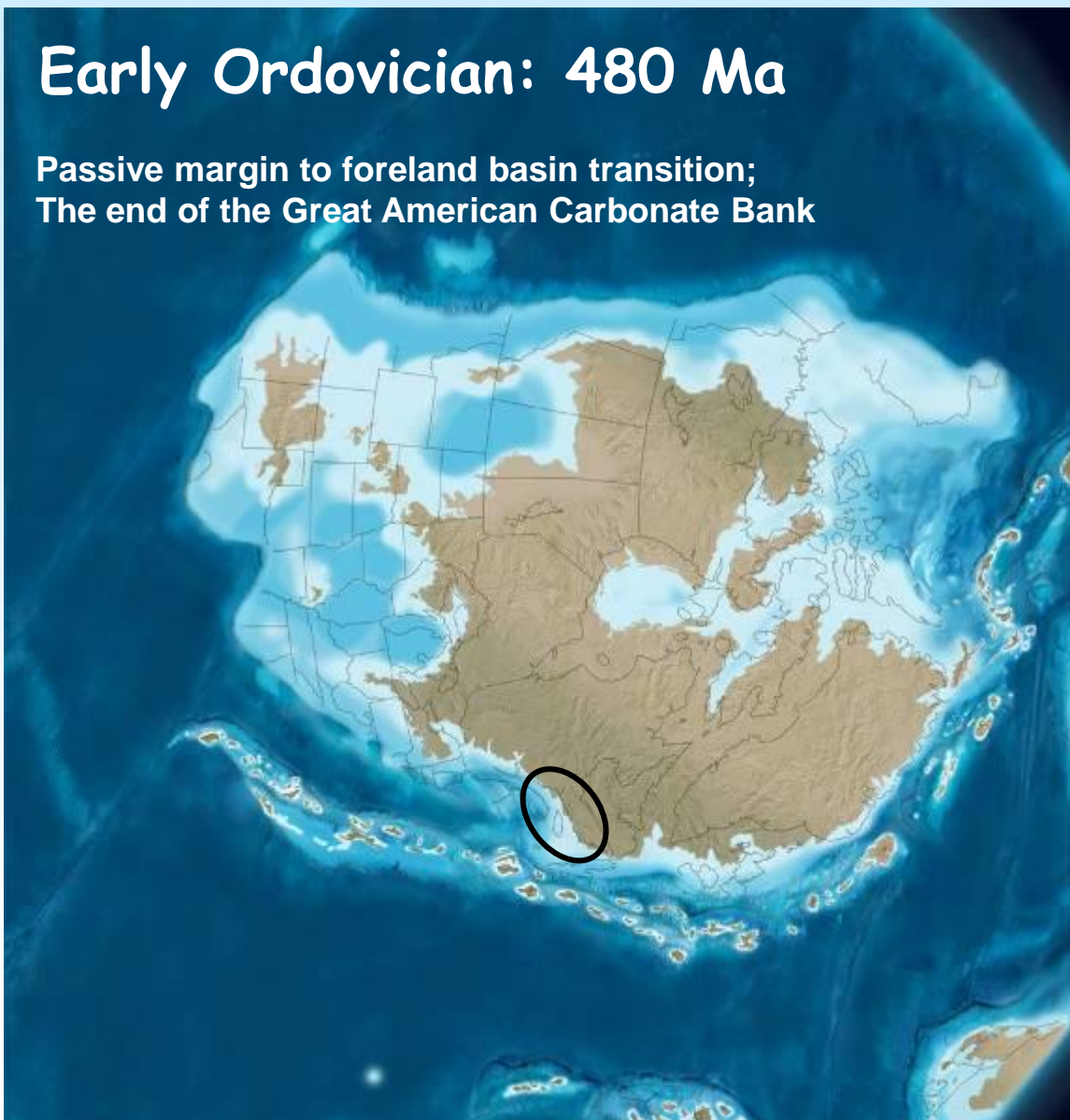


Blakey (Un of Arizona)



Early Ordovician: 480 Ma

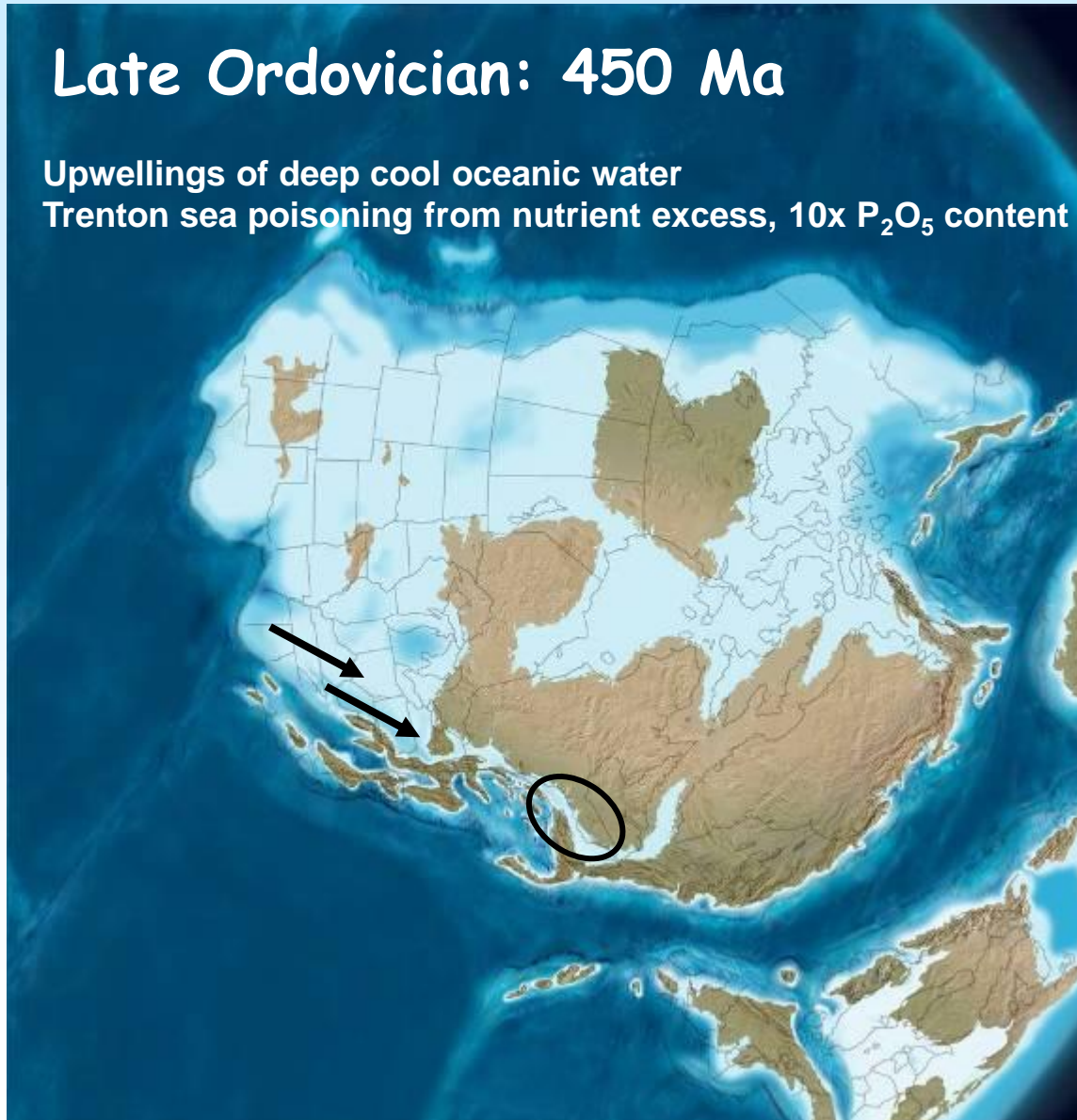
Passive margin to foreland basin transition;
The end of the Great American Carbonate Bank



Restricted oceanic circulation

Late Ordovician: 450 Ma

Upwellings of deep cool oceanic water
Trenton sea poisoning from nutrient excess, 10x P_2O_5 content





Thermal maturation and organic geochemistry

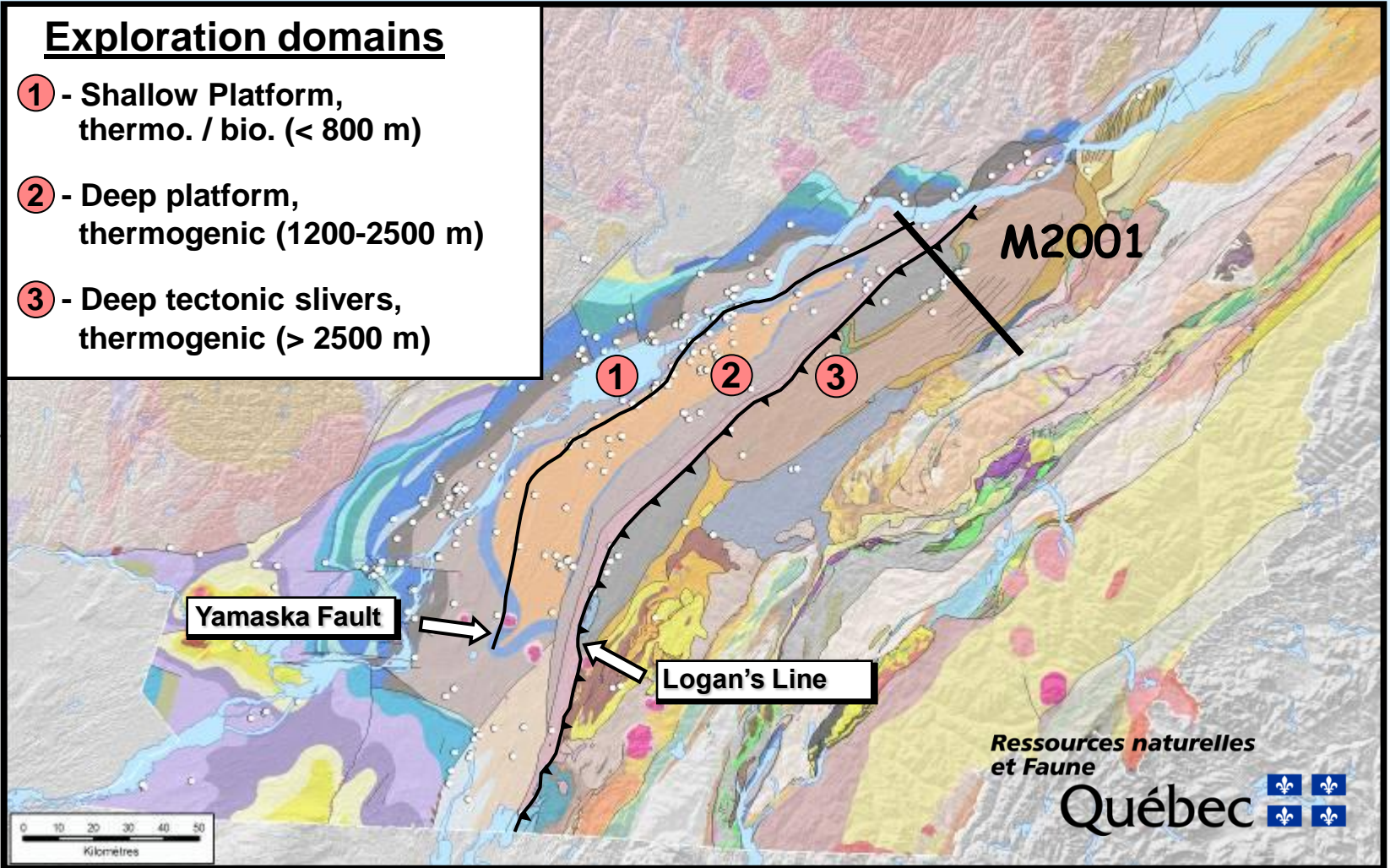
Available public domain data



THE CURRENT STATUS OF PUBLIC DOMAIN DATA

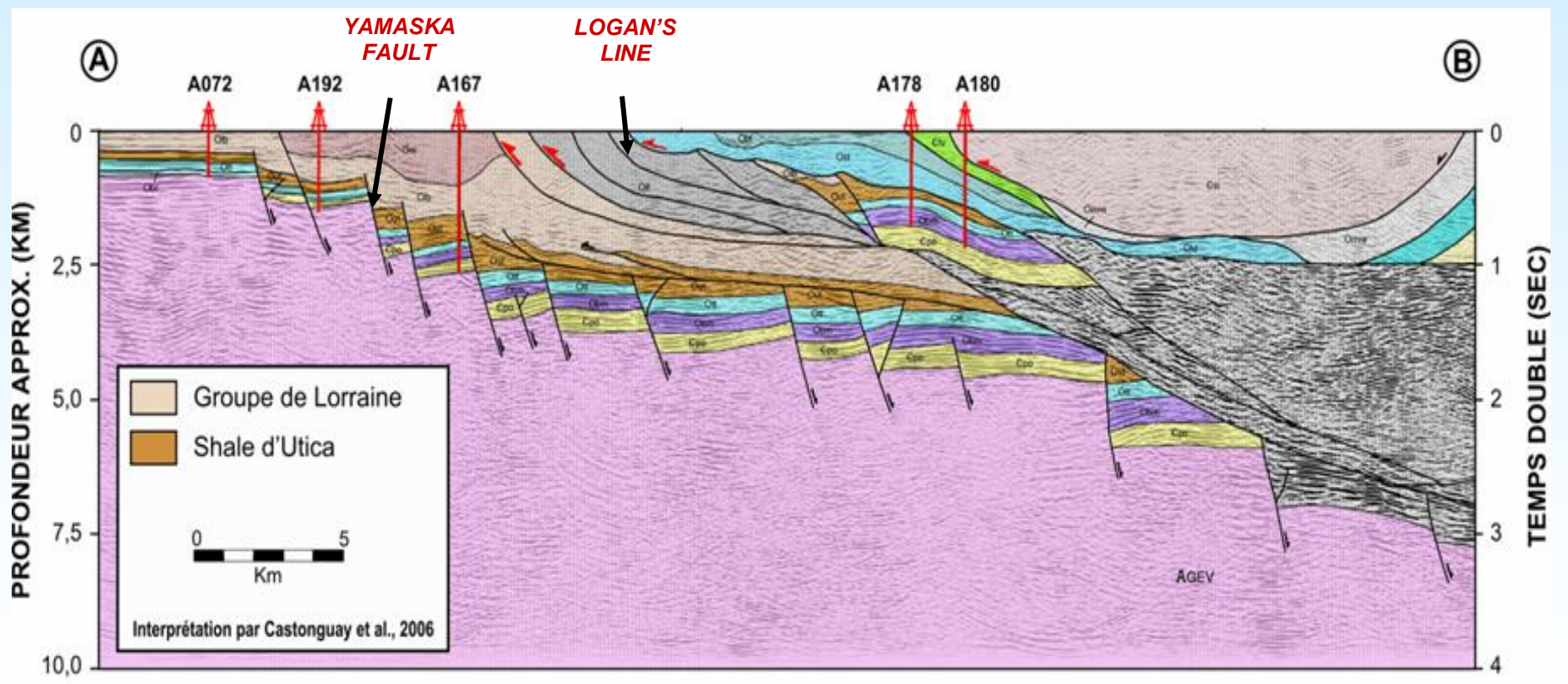
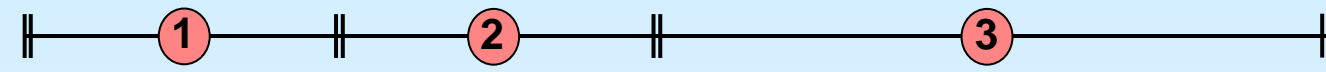
Exploration domains

- ① - Shallow Platform, thermo. / bio. (< 800 m)
- ② - Deep platform, thermogenic (1200-2500 m)
- ③ - Deep tectonic slivers, thermogenic (> 2500 m)

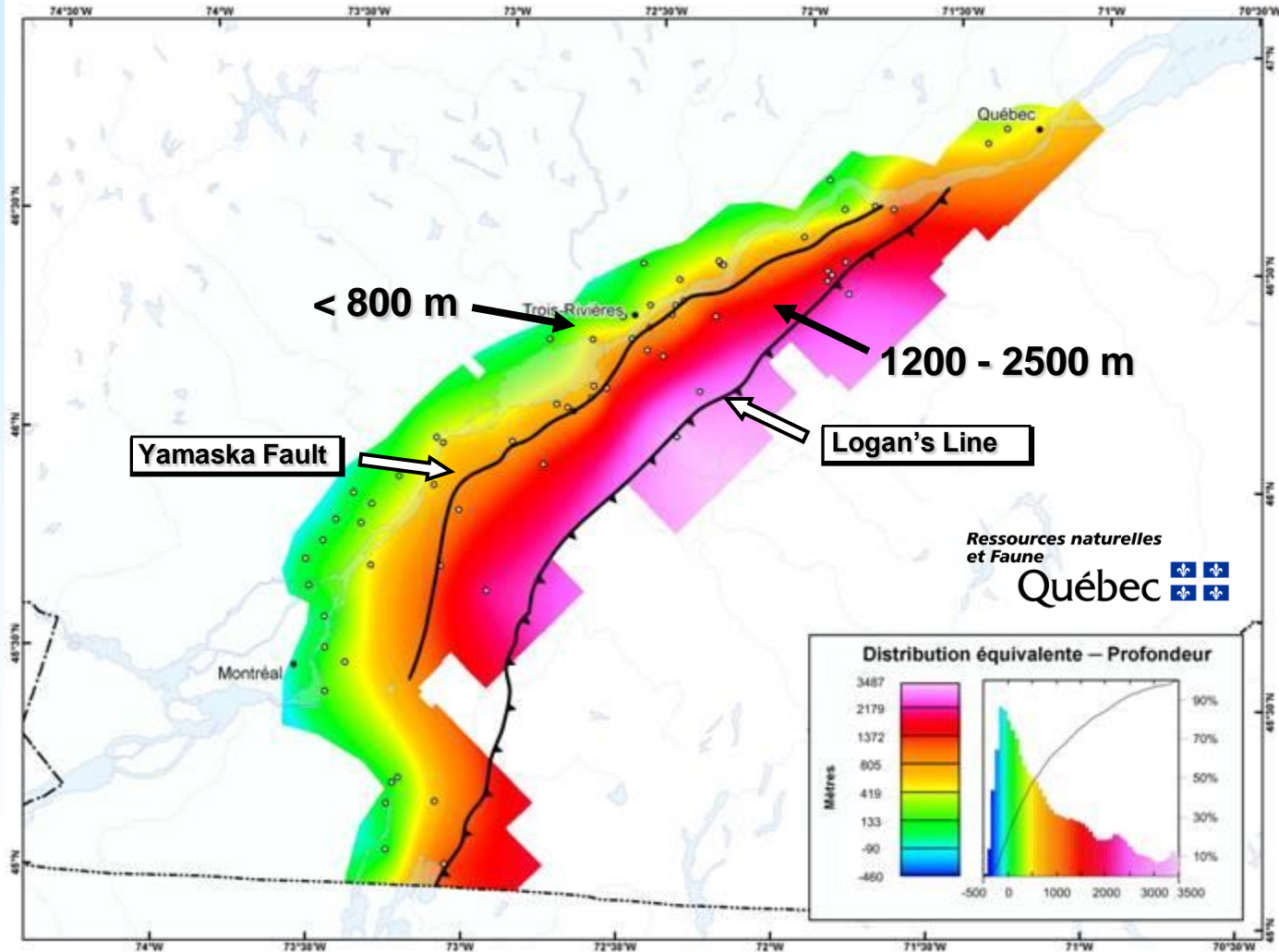




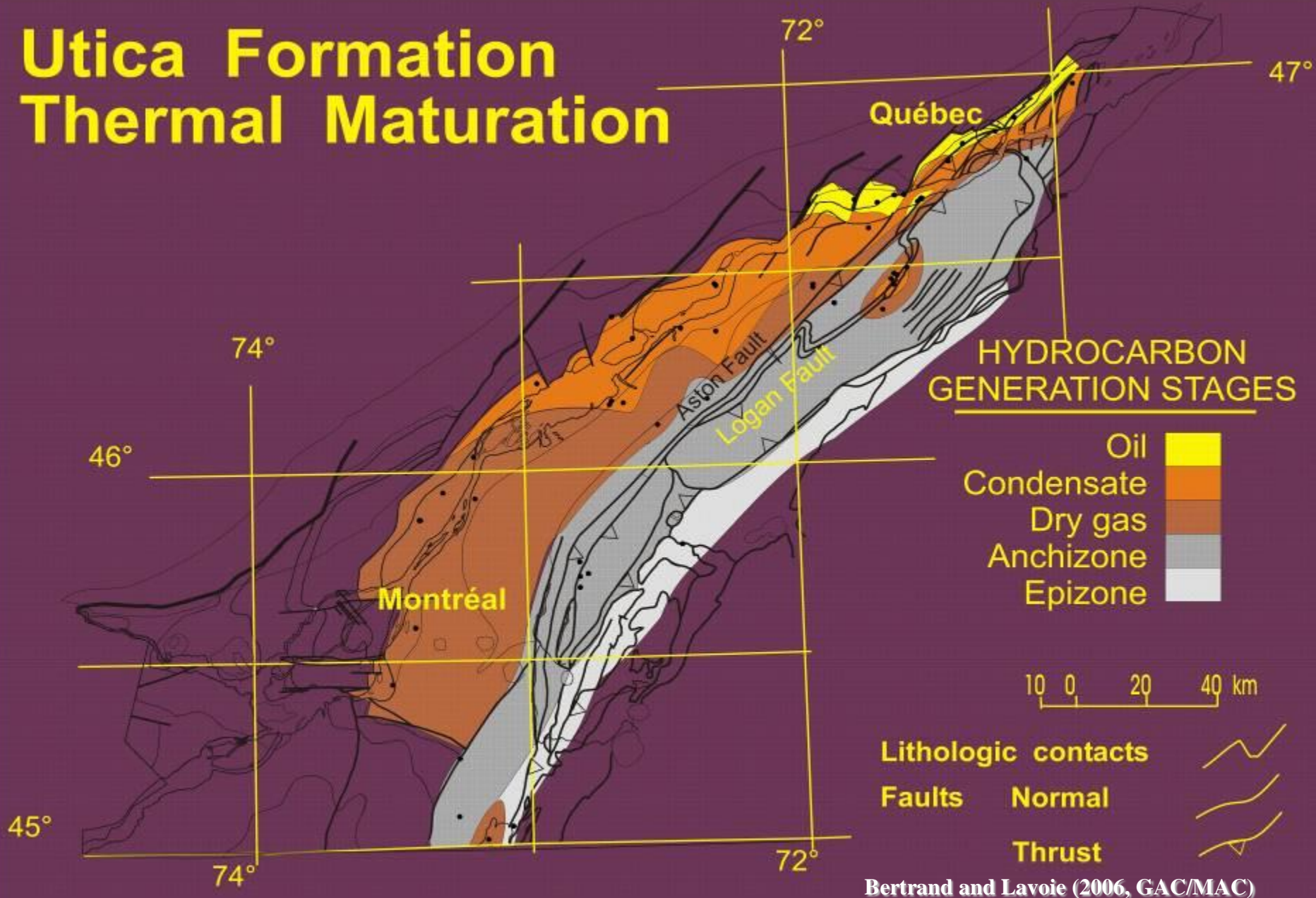
M-2001 Seismic line



Depth to the top of the Utica Shale



Utica Formation Thermal Maturation

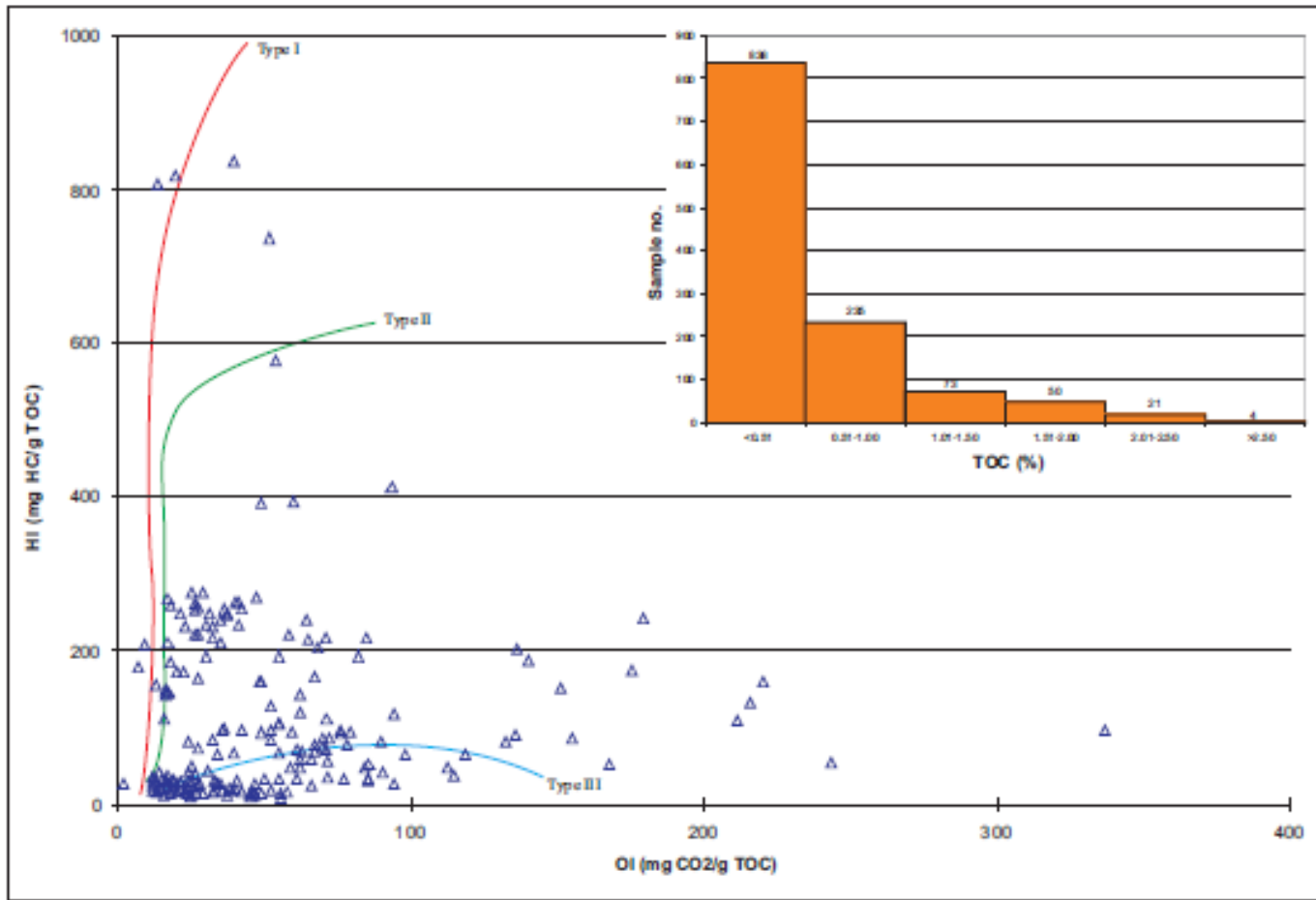


- Maturation increases from oil in N-E Lowlands to dry gas SW of it.

Utica - Lorraine well data



Cambrian-Ordovician St. Lawrence well samples



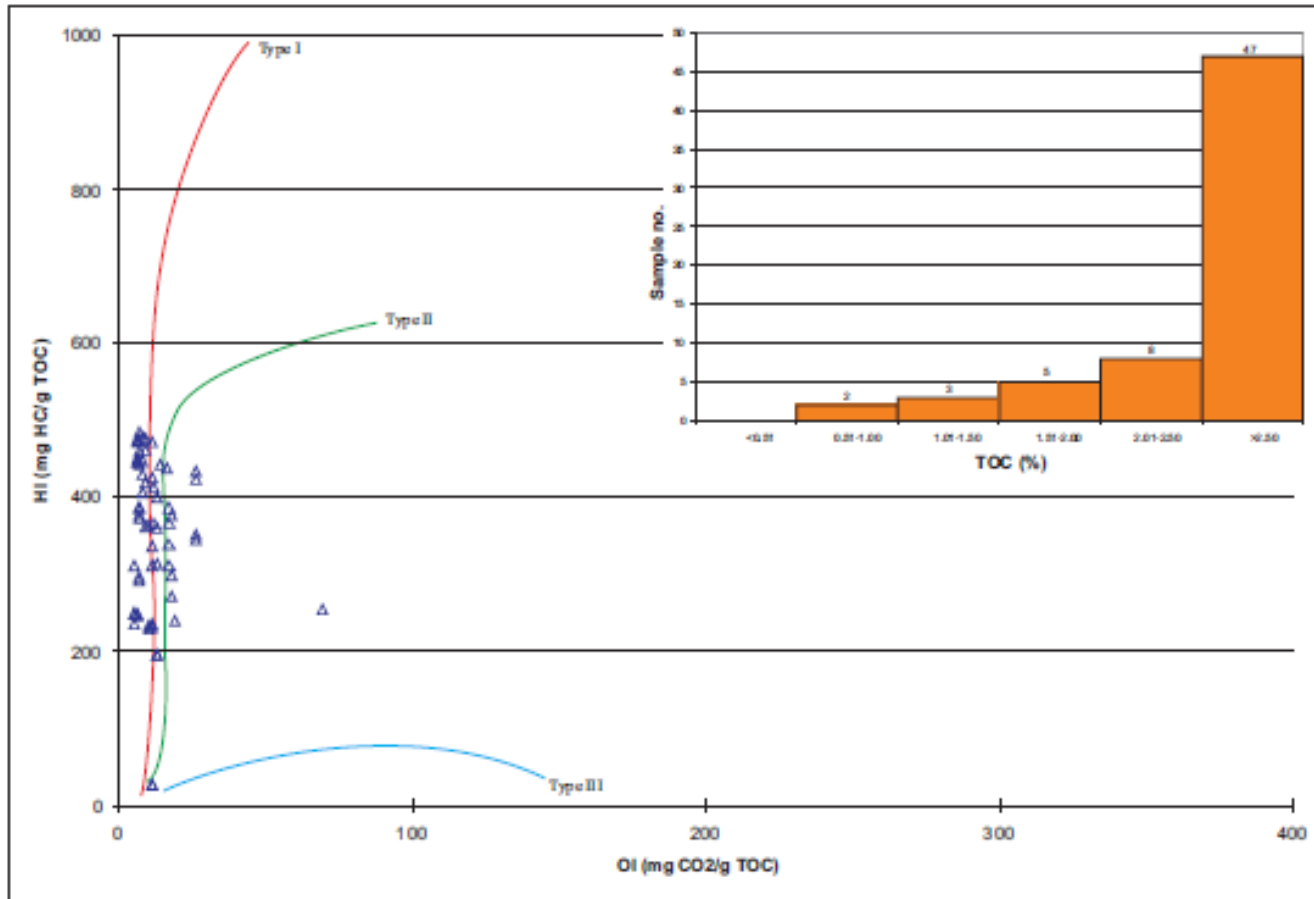
Lavoie et al. (2010; GSC Open File 6050)



Macasty (Anticosti)



Ordovician Anticosti well samples



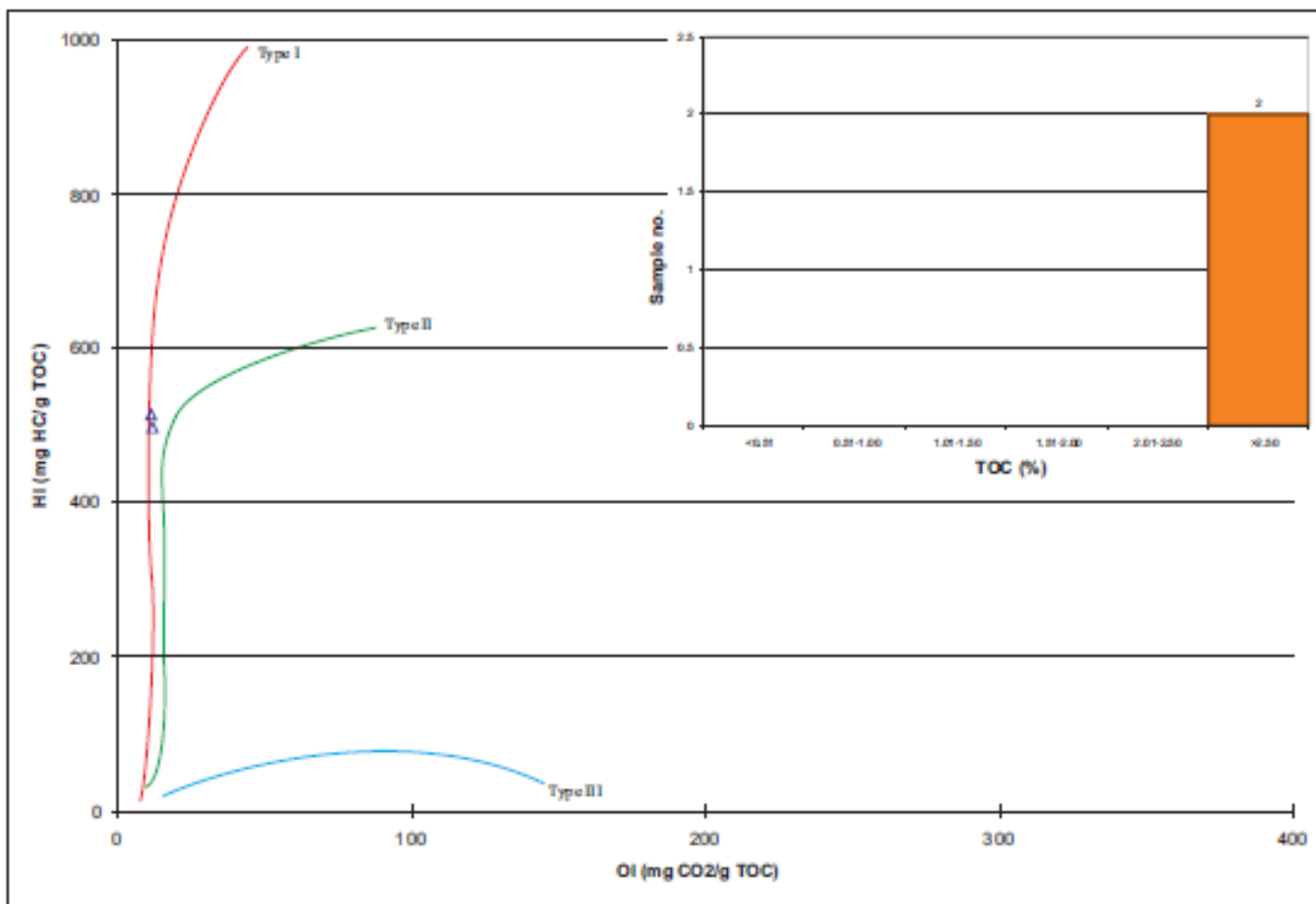
Lavoie et al. (2010; GSC Open File 6050)



Pointe-Bleue (Lac St. Jean)



Ordovician St. Jean well samples



Lavoie et al. (2010; GSC Open File 6050)

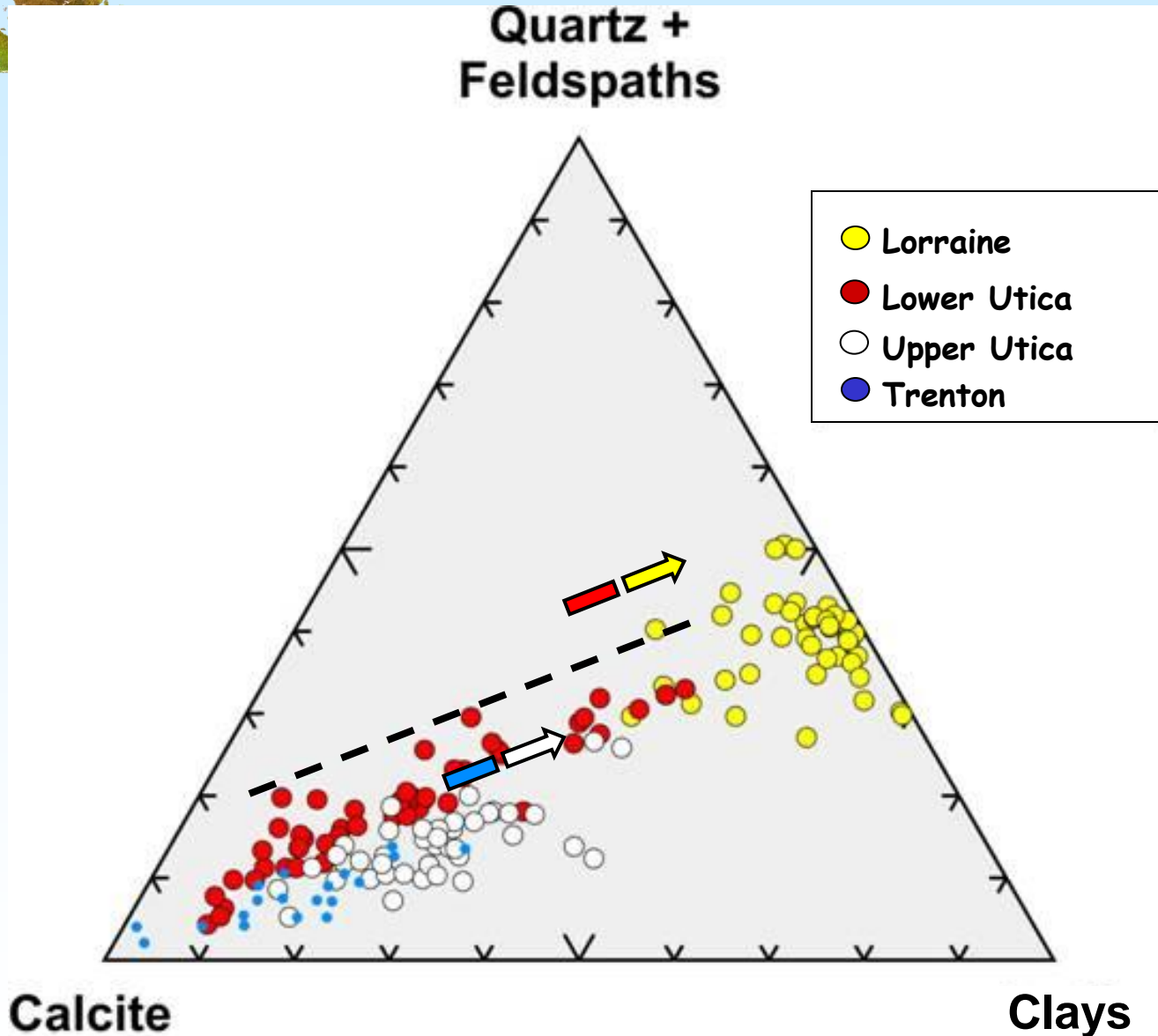


Natural Resources
Canada

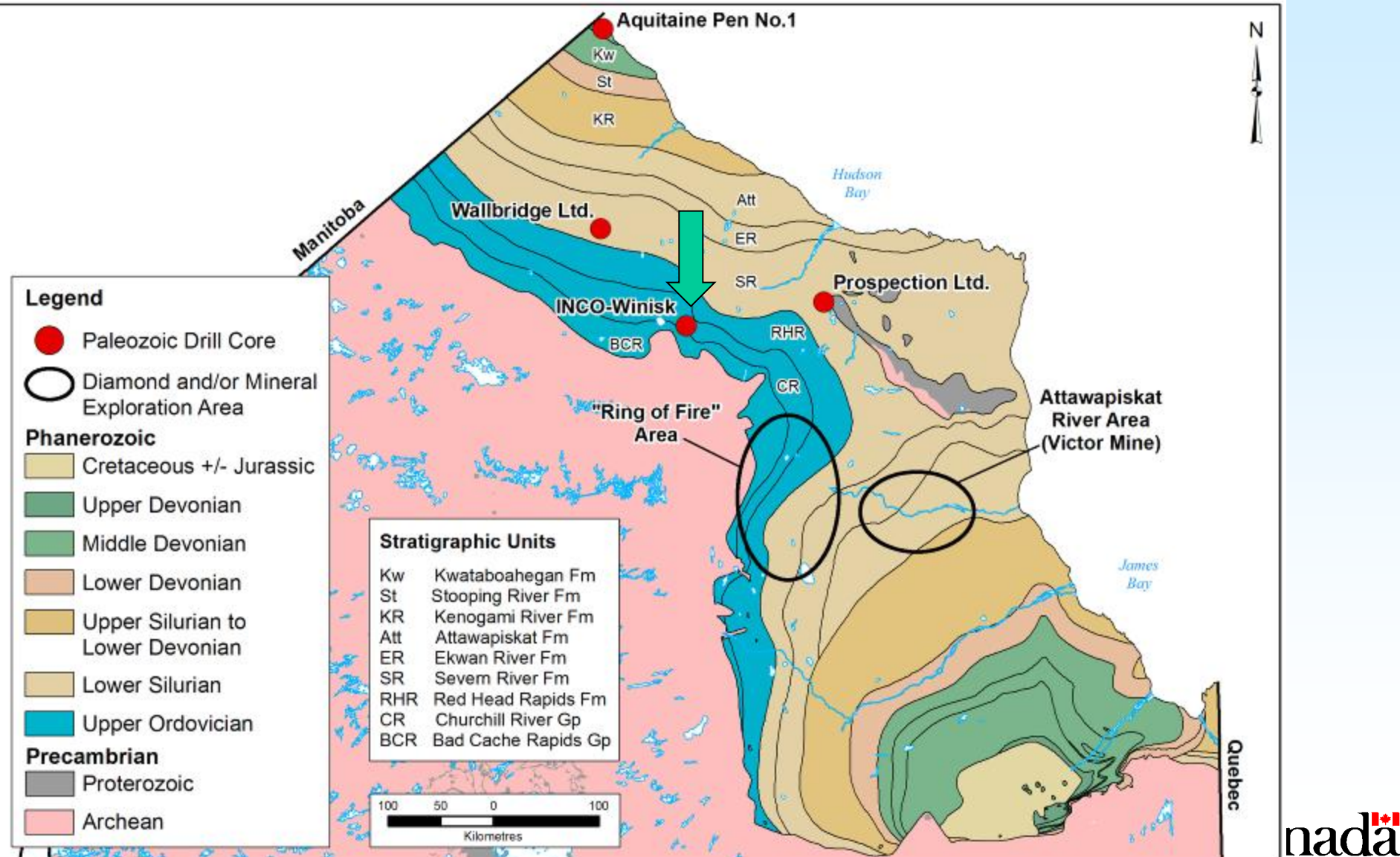
Ressources naturelles
Canada

Canada

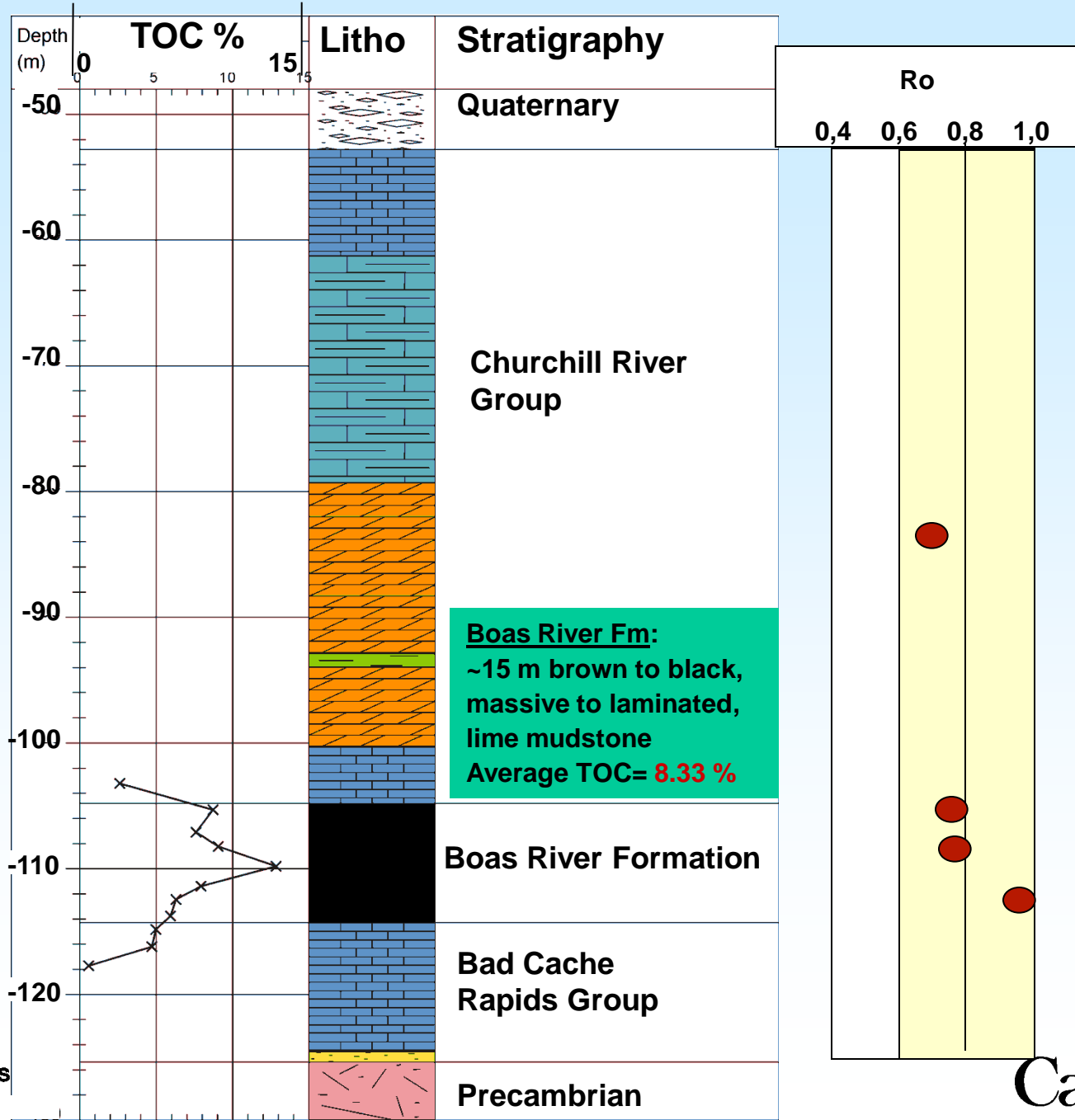
Mineralogy - X-Ray Diffraction



Upper Ordovician Boas River Shale in northern Ontario



Upper Ordovician Boas River Shale in northern Ontario



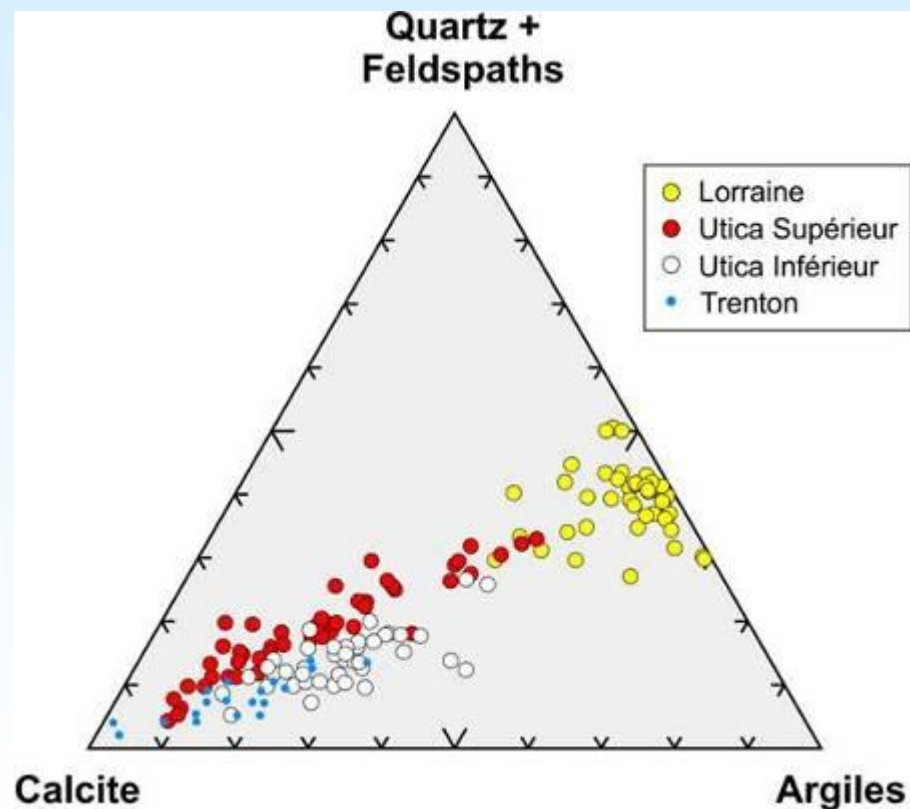
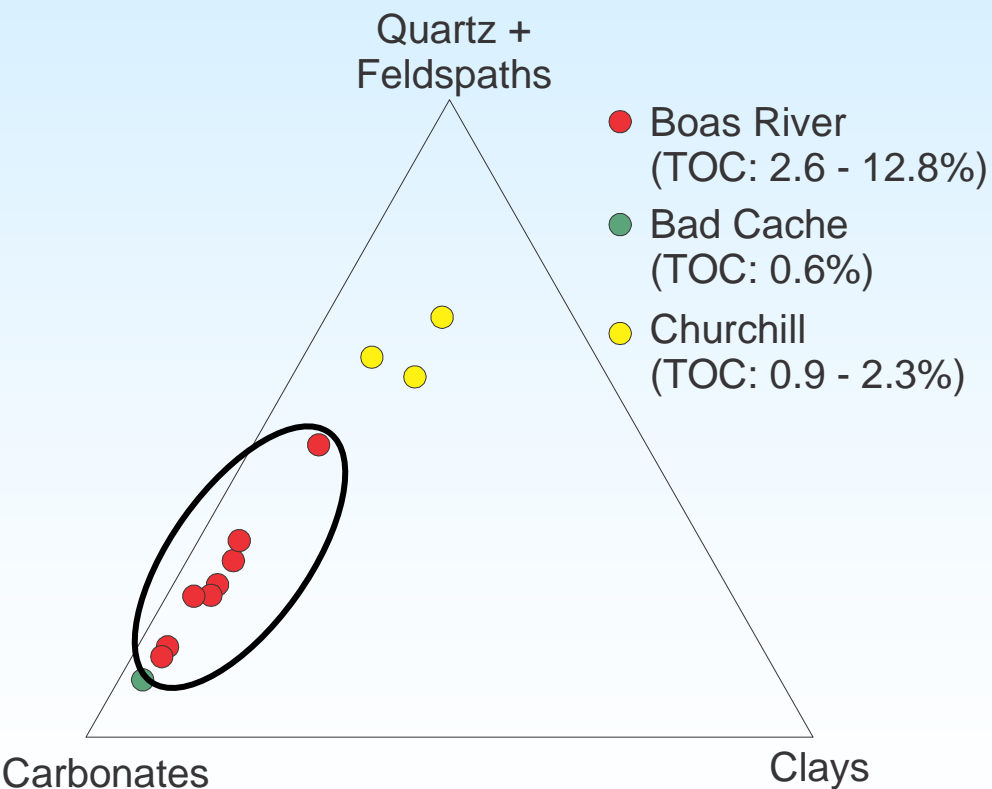
Ordovician black shale Northern Ontario



15% TOC

Boas River Shale in northern Ontario

A new shale gas (biogenic) play ?



Thank you!

